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## ASTRONOMICAL PANORAMIC VIEWS FROM A CITY OBSERVATORY.*

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The astronomical panoramic views presented in this article were taken for the purpose of teaching students the circles of the celestial sphere and the magnitude of circular measure. They consist of a series of eight photographs, taken from the dome of the Creighton University Observatory, towards the eight principal points of the compass, and have drawn upon them the circles of altitude, azimuth, declination and hour angle at intervals of five degrees. The diurnal paths of the stars and their points of rising and setting, as well as other connected details, may thus be studied with reference to fixed terrestrial objects. It is the purpose of this article to explain the method used in the construction of the lines on the photographs.

How well the Creighton University Observatory is situated for such a series of views, and how exceptionally large is the extent of sky it commands in spite of its position in the very heart of a city of 120,000 inhabitants, is aptly suggested by Fig. 1, Plate XIV, in which it is seen to be placed upon the summit of a hill. The nearest part of the street in the foreground is seventy feet from the dome and fifty feet below the telescope, while the next street beyond and back of the Observatory is seventy-five feet below. There is little or no danger of ever encroaching upon this extensive view except between the south and west, as will be seen later.

Fig. 2, Plate XIV, gives a nearer view of the Observatory. Its eleva-

* Read at the Atlanta meeting of the Astronomical and Astrophysical Society of America, December 30, 1913.

tion of ten feet above the lawn is due to the grading necessitated by the cutting through of the street to the right or east of it. A retaining wall was then built about the Observatory itself, so that its position was never disturbed. Although there is a double line of cars on the street, the vibrations of the telescope, even with its highest powers, are scarcely noticeable.

The photographic camera was placed as far inside the dome as the width of the slit allowed. In the first series of views, taken on June 8, 1913, the camera was exactly on a level with the telescope, that is to say, at the height of the intersection of its polar and declination axes. In the second series, taken August 22, 1913, the camera was raised 2.8 feet in order to clear the transit roof and catch the bluffs and river towards the east. The information furnished by a study and measurment of the first set was an enormous help towards the success of the second. One preliminary view of the set would have been a necessity at all events in order to obtain the scale.

A small Gurley reconnoissance transit having been placed above the intersection of the axes of the equatorial, the altitudes and azimuths of a number of prominent objects were measured. The meridian was

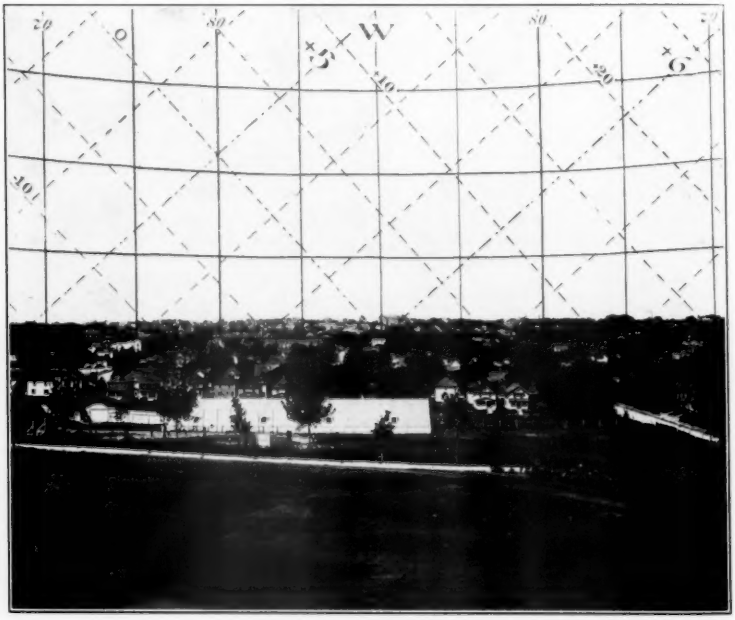



FIGURE 3. TOWARD THE WEST.

found from Polaris, which with the facilities afforded by a fixed 3-inch transit and a sidereal clock, gave greater accuracy than was needed.

The first attack upon the photographs consisted in finding the effective focal length of the lens. This was determined from the southeast view by measuring the horizontal linear distances of about fifteen objects from the center of the picture. As the photograph was a plane surface, perpendicular at its mid-point to the optical axis of the lens, and tangent to the sphere whose center was at the optical center of the lens, and whose radius $R$ was the focal length of this lens, the linear distances measured were each equal to $R \tan A$; $A$ being the difference of azimuth or of bearing of the objects and the midpoint of the photograph. The mean of the fifteen measures gave $R = 12.01$ inches. It was taken as evident therefore that the optician had intended to make the focal length exactly one foot.

A complete reseau or network of altitudes and azimuths could now be constructed. A horizontal line was drawn on transparent paper, and at distances in inches of twelve times the tangent of every degree as far as 25°, parallel vertical lines were drawn perpendicular to the horizontal line. On every fifth one of the vertical lines, points were

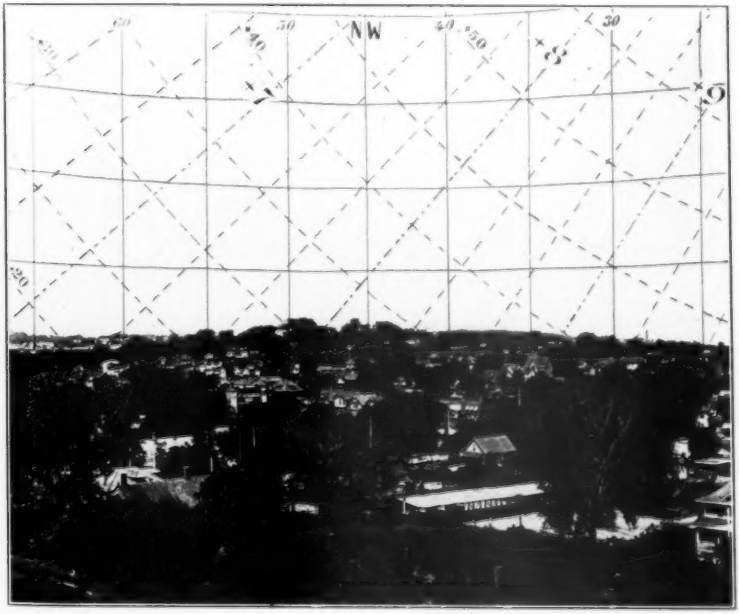



FIGURE 4. TOWARD THE NORTHWEST.

marked at distances from the horizon line of $R \sec A \tan h$; $A$ and $h$ being each taken at intervals of five degrees, but $h$ going only as far as 20° in altitude. The curves connecting corresponding points were then the lines of equal altitudes and are shown on all the panoramic views. They are known as almucantars. On the paper mentioned before the intermediate curves were added for every degree, so that, when completed, the reseau properly applied to any of the views marked every degree of altitude and of difference of azimuth. Taking the horizon line and the middle vertical line on any photograph as axes of reference, a mathematician would say that the coördinates of any point whatever would be $R \tan A$ and $R \sec A \tan h$, in which $h$ is its altitude and $A$ its difference of azimuth from the center of the picture.

The next operation was the longest of all, but as it had been prepared in part and used for other purposes before, the labor was considerably abridged. It consisted in the computation of the position of the declination and hour circles, without which the motions of the stars cannot be understood. To effect this, the declination $\delta$ and the hour angle $\tau$ were taken for every five degrees as far as they were needed. and the corresponding azimuth $A$ and zenith distance $\zeta$ computed. The formulae used were the general ones:

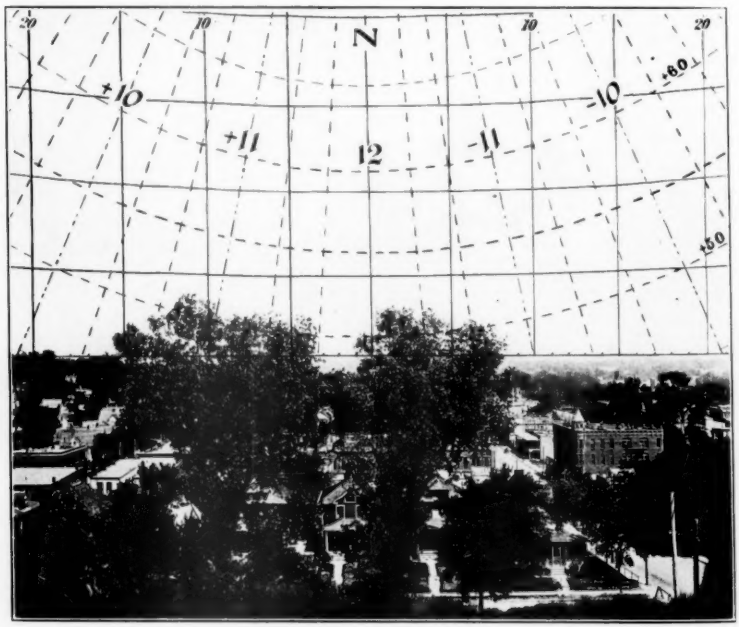



FIGURE 5. TOWARD THE NORTH.

$$\tan M = \frac{\tan \delta}{\cos \tau}$$

$$\tan A = \frac{\tan \tau \cos M}{\sin (\phi - M)}$$

$$\sin \zeta = \frac{\cos \delta \sin \tau}{\sin A}$$

When the results had been tabulated, each of the panoramic views of the first set was taken in turn,—blank sheets of paper would have served the purpose—placed face downward upon the reseau and properly adjusted, both lying on a glass plate with an electric lamp below it. The intersection points of the declination and hour circles were then plotted from their computed azimuths and altitudes, and corresponding points joined by smooth curves. The declination curves, the same as the almucantars, being the projections of small circles of the sphere, are hyperbolas when $\pm \delta < \phi$, parabolas when $\pm \delta = \phi$, and ellipses when $\pm \delta > \phi$. The hour and azimuth circles, however, being great circles of the sphere, are projected into straight lines.

When the curves were smoothed, they were drawn in ink on the backs of the photographs. It was an easy matter then to transfer

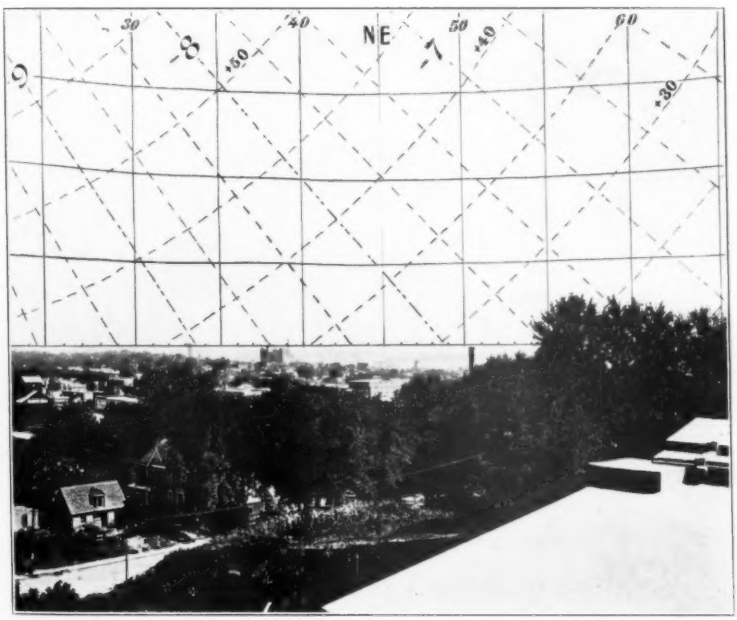



FIGURE 6. TOWARD THE NORTHEAST.

them from the first to the second set. Here they were drawn upon the faces of the views and properly numbered. They were then mounted on cardboard and photographed individually at the same distance. From this third series of negatives, the lantern slides shown at Atlanta were made and positives printed for the cuts of this article. With the exception of the lantern slides the photographic work was all done by Alphonse R. Schmitt, my associate professor of physics and director of the Creighton Camera Club. The excellence of the work is its own commendation.

It may be acceptable to mention briefly some of the more interesting landmarks shown on the views.

The western prime vertical passes almost exactly through the middle of the south gable of the Sacred Heart Convent, whose whole south roof and entire north wing were demolished by the tornado of Easter Sunday, March 23, 1913. Behind the convent, the new cathedral may possibly be discerned. Its cross was erected the day after the photograph was taken. In the northwest, the tornado passed about two blocks beyond the building prominently located in azimuth 50°. This was three-quarters of a mile from the Observatory, its nearest approach.

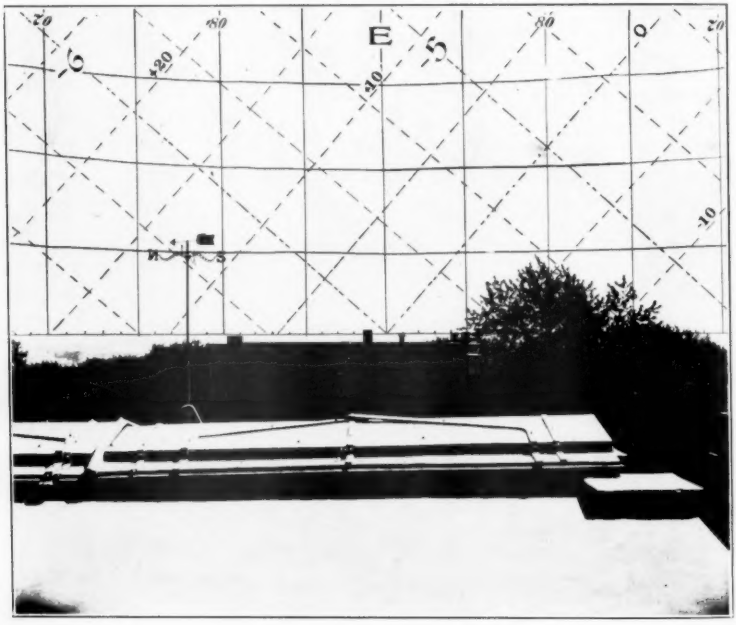



FIGURE 7. TOWARD THE EAST.

The hour lines, which are strictly parallel on the west view, show a decided convergence on this one, and the declination circles are considerably curved.

On the north view, the hour lines converge to the north pole, which is at an altitude of $R \tan \phi$, $\phi$ being the latitude of the place, 41° 16′. Hidden by the tree in altitude − 0° 2′ and azimuth N 0° 54′ E is a water tank more than two miles away. When the leaves fall, this object and the convent gable in altitude +1° 36′ and azimuth N 89° 56′ W make superb land marks for the adjustment of the equatorial.

In the northeast picture, the line of bluffs is in places the true astronomical horizon.

In the east view the bluffs are scarcely a quarter of a degree above the true horizon. We here get a glimpse of the Missouri River with one of its three bridges.

The southeast photograph looks towards the business center of the city. In azimuth 55° to 58° we may possibly see the Union Pacific headquarters, the Woodmen of the World building at 47°.5 to 50°, while the third skyscraper of which Omaha can boast is hidden by the trees

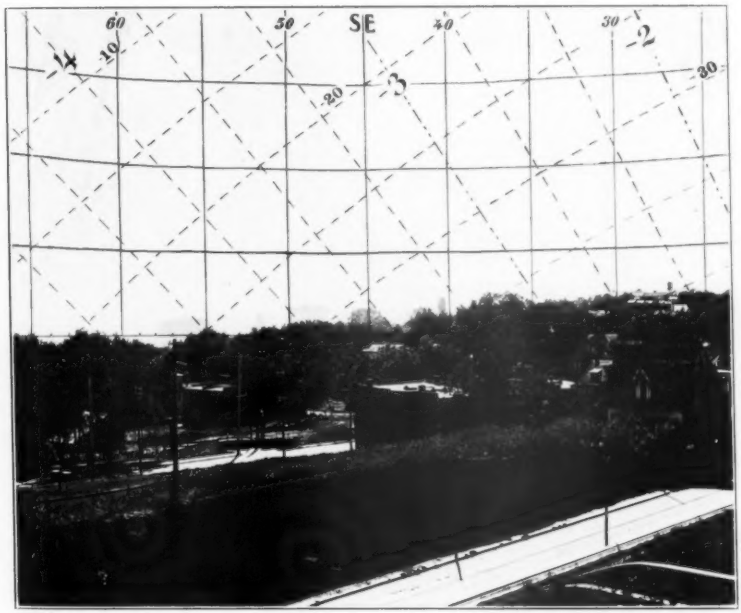



FIGURE 8. TOWARD THE SOUTHEAST.

at 40°. The building 25° to 32° is our million-and-a-half dollar high school, on the site of the old capitol. The declination circles now reverse their curvature and the hour lines converge below the horizon.

In the south and the southwest views the college building, technically the Undergraduate Department, or the Arts and Science Building, offers the only considerable obstruction. A special photograph of this building in its entirety is shown in another cut. Its interference made itself felt last September when the moon at first quarter ran in declination —28° and was hidden behind the college just when it was at its best. As the photograph enabled me to foresee this, I had to defer visitors to other dates. But as this contingency rarely happens, and as the view of the sky descends everywhere else to within a couple of degrees of the true astronomical horizon, it is really astonishing that a city observatory should command such an extensive view.

If the reader is inclined mathematically, he will find the study of these panoramic views very interesting. As the college building faces the points of the compass accurately, the vanishing point of its east front will be found in the south point of the horizon, and that of its north side in the west point of the horizon. This latter point will be found

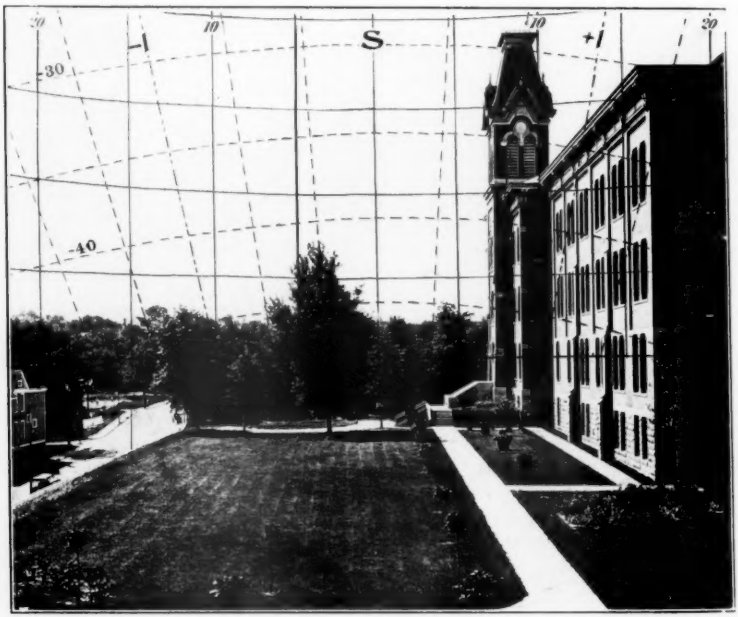



FIGURE 9. TOWARD THE SOUTH.

at a distance of $R \tan 45° = R$ to the right of the middle of the southwest picture. In the photograph of the college building in its entirety. the center of the picture is in azimuth S 26° W. The south or left, vanishing point is therefore at a distance of $R \tan 26°$ and the west or right one at a distance of $R \cot 26°$.

The point of convergence of the hour lines in the north view has already been mentioned. Its coördinates are $x = 0, y = + R \sec 0° \tan \phi$ In the south view, they are $x = 0, y = - R \sec 0° \tan \phi$. In the northeast and northwest views, they are respectively $x = \mp R \tan 45°$, $y = + R \sec 45° \tan \phi$. In the southeast and southwest pictures, similarly $x = \pm R \tan 45°$, $y = - R \sec 45° \tan \phi$. In the east and west views they are both at infinity, the hour lines being strictly parallel and making an angle of $\phi$ (the latitude) with the horizon. Their distances from the 6-hour line are $R \tan (6^h \pm \tau)$.

The azimuths, $\alpha$, of the points where the hour lines intersect the horizon, are the same as those of the hour lines on a horizontal sun dial, the formula being $\tan \alpha = \sin \phi \tan \tau$. On the north and south pictures, the hour lines make angles $\gamma$ with the meridian such that $\tan \gamma = \cos \phi \tan \tau$, the same as on a prime vertical sun dial, the east and west views being meridian sun dials.

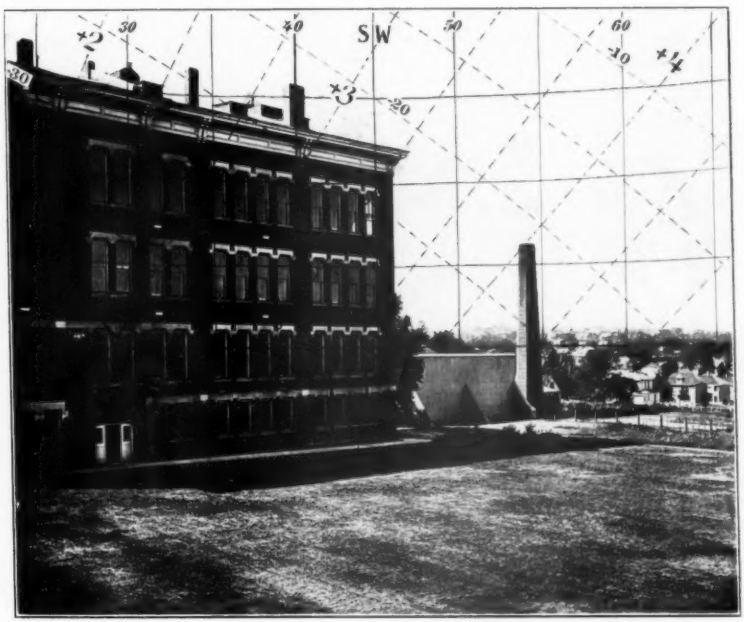



FIGURE 10. TOWARD THE SOUTHWEST.

A considerable discontinuity may be noticed between the south and the southwest pictures when they are compared with the photograph of the whole college building. This is due to the fact, observable only in this instance, that owing to the narrowness of the slit, the camera could not be placed in the very axis of the Observatory dome. It was therefore carried around in a circle of about 5 or 6 feet radius. This made near objects like the college building appear larger, and thus shoved their margins off the plate. In addition, there is an hiatus of about two degrees between all adjoining views, because their horizontal stretch is only 43°.

The original photographs of the second set in which the focal length of the lens is exactly one foot, have been mounted on the sides of a regular octagon, so that by placing the eye at the center of this octagon and on the level of the horizon line, one can have precisely the same view that he would have from the dome of the Observatory. In this way, besides becoming acquainted with the circles of the celestial sphere and the direction and velocity of motion of stars in various parts of the sky, the student may also learn something of angular magnitude and be able to locate the points of rising and setting of any heavenly body and to predict its position at any time, provided its altitude does not exceed 20 degrees. In order to remove this last restriction, it

FIGURE 11. MAIN BUILDING, CREIGHTON UNIVERSITY.

PLATE XV

SETH CARLO CHANDLER
1846–1914

occurred to me to extend the planes of the photographs to the altitude of 45 degrees and to roof them over with transparent celluloid, so that the entire celestial sphere would be represented with its two systems of coördinates. However, upon maturer reflection, I think that this mathematical completeness would bewilder the student. It would make the apparatus too cumbersome and prevent its convenient comparison with the sky. One great circle and four great semicircles of wire, of one foot radius, have however been added, to indicate the horizon, the meridian, the prime vertical, the equator and the six hour circle, as well as to show that the planes of the photographs are tangent to the sphere and are its gnomonic projection. The whole contrivance has proved such a success that the construction of a larger one of four foot radius has already been begun.

## SETH CARLO CHANDLER.

ARTHUR SEARLE.

Seth Carlo Chandler, son of Seth Carlo and Mary (Cheever) Chandler, of Boston, Massachusetts, was born in that city on September 16, 1846 His future career was to some extent indicated in his boyhood by an interest in accurate mechanical contrivances, which often induced him to carry off the kitchen clock in order to use some of its parts in machinery of his own invention, although he always restored it in good order to its proper functions, until finally it was handed over to him permanently. He was not allowed the same privilege in the case of the sewing machine, but it soon appeared that when that required any adjustment, he could put it to rights better than any other member of the family. His liking for precision of statement and of observation is apparent in a juvenile letter of the year 1861, dealing with the exact number of hours of school-time before vacation, and with the daily growth of a vine.

His education was obtained in the public schools of Boston, and while still a pupil in the English High School he was employed in computations for the performance of which Professor Peirce, of Harvard University, had requested the master of the school to recommend some one. This circumstance seems to have been the immediate cause of his entrance, after finishing his course at the school, upon practical work in mathematics and astronomy, in connection with which his subsequent studies were carried on without formal instruction.

As early as 1862, he was assisting the distinguished astronomer Dr. B. A. Gould, and continued for the remainder of Dr. Gould's life to be closely associated with him in scientific work and in friendship, although declining to accompany him to Argentina in 1869, at which time Chandler was soon to be married. Before this, in 1864, he was employed with the title of Aid in the work of the U.S. Coast Survey, and remained in that position till 1870. In the course of his Coast Survey service, he made expeditions to Machias, Maine, and to Galveston, Texas.

His marriage, October 20, 1870, to Caroline Margaret Herman, of Boston, who, with several daughters, survives him, combined with the temporary absence of Dr. Gould to turn his attention for a time to some more lucrative occupation than could be offered by science. His new employment was that of actuary for the Continental Life Insurance Co., which he had undertaken more than a year before his marriage. This required his removal to New York, and he resided in that city or its vicinity until 1877, when he returned to Boston as consulting actuary for the Union Mutual Life insurance Co.

His financial circumstances now permitted him again to devote himself to his favorite pursuits. In 1881 he settled in Cambridge, Massachusetts, near the Observatory of Harvard College, in the work of which he took part, at a nominal salary, for a few years, subsequently conducting his researches as an independent astronomer. He removed his residence in 1904 to Wellesley Hills, Massachusetts, where he died on December 31, 1913, after a short illness of pneumonia.

No more than a very slight sketch of his astronomical achievements can here be attempted. His published treatises are mainly to be found in the *Astronomische Nachrichten*, the *Astronomical Journal*, and the *Annals* of the Observatory of Harvard College. They relate to a great variety of subjects, the most important of which will here be classified as practical astronomy, theoretical astronomy, variable stars, the variation of latitude, and the constant of aberration.

1. *Practical Astronomy.* Under this heading will be included Chandler's services to what may be called astronomical business matters. After the death of Dr. Gould, he became the chief editor of the *Astronomical Journal*, which he conducted from December, 1896, to September, 1908, when he transferred this labor to Professor Boss. In partnership with Mr. John Ritchie, Jr., he contrived in 1881 an ingenious system for the transmission of astronomical intelligence by telegraph, adapted to the rules then in force in telegraph offices. This system proved practically serviceable, and was of great use for several years. It enabled a well known dictionary, easily obtained, to be used as a cipher code. A small instrument for ascertaining the time by observations of the sun without the use of a telescope was invented by

Chandler about the same time. But his principal addition to astronomical apparatus was the almucantar, an azimuth instrument floating in a shallow basin of mercury, and described in Volume XVII of the *Annals* of Harvard College Observatory. No further account or discussion can here be undertaken of this remarkable instrument, for which the medal of the Massachusetts Charitable Mechanics Association was awarded to its inventor.

The almucantar used by Chandler was afterwards employed by Professor Brown at De Pauw University, Indiana, from which institution Chandler received in 1891 the honorary degree of LL.D.

2. *Theoretical Astronomy.* Chandler's activity in this branch of his science related chiefly to the determination and discussion of cometary orbits. He was a rapid and accurate computer, and has been known to amuse himself by obtaining a needed third observation of a comet in an evening, and then completing during the same night the calculation of the elements of its orbit. The most interesting of his numerous publications relating to comets is probably his identification of comet *d* 1889 with Lexell's Comet of 1770, (*Astronomical Journal*, Vol. 9, page 100) in which he examines the effect of the perturbation by Jupiter of the comet's orbit in particular years when it made a close approach to that planet. Another research of special importance which he undertook was one dealing with the orbit of the small planet Eros, and leading to the discovery that its position in its particularly interesting opposition in 1894, some years before it was known to exist, could be determined from the photographs preserved at Harvard College Observatory. No detailed account of these investigations can here be given.

3. *Variable Stars.* Objects of this class were the first which attracted Chandler's attention, and continued almost throughout his life to be one of his favorite studies. He independently discovered the "new star" of 1866, known subsequently as *T Coronae*, which suddenly increased its brightness in that year. A long list of observations and discussions of variables, subsequently made, must here be passed over without notice. Three successive catalogues of variable stars, the last published in 1896, display the energy and perseverance of Chandler in collecting and discussing the constantly increasing material provided by observers. One special treatise on the inequalities in the period of Algol (*Astronomical Journal*, Vol. 11 page 113,) may be mentioned, as it contains a highly ingenious theory, not as yet well supported by observation, with regard to a supposed invisible companion to that star, more distant from it than the dark body which is generally admitted to be the cause of the observed changes of light.

4. *Variation of Latitude.* In order fully to understand the value of Chandler's work upon this subject, the reader must acquaint himself with its previous history. All that can here be said is that Chandler planned and executed with great skill and industry an examination of the evidence to be derived from observations of the eighteenth century and later for the existence and the modifications of this variation. He once said humorously that he was about "to add a hundred feet to Bradley's monument", by showing that supposed errors of observation in the work of that astronomer really gave evidence of accurate measurements of a phenomenon unknown in Bradley's time. Chandler was able, from the previously neglected testimony of former observers, to construct a theory of the movement of the pole which he could use in successful predictions of the changes under actual observation in his own time. For these researches he was awarded, in 1895, the Watson gold medal of the National Academy of Sciences in this country, and, in 1896, the gold medal of the Royal Astronomical Society in London. In this last case, Chandler's work on variable stars and other astronomical investigations were mentioned as additional reasons for the award of the medal.

In 1901, if it had been practicable for him to have visited Glasgow, the University of that city would have confrerred on him a doctor's degree.

5. *Constant of Aberration.* As is known, this subject is intimately connected with that of the variation of latitude, and Chandler accordingly discussed it in several publications of importance which must here be dismissed with this brief mention.

Chandler was a Fellow of the American Academy of Arts and Sciences, a member of the National Academy of Sciences, and a Foreign Associate of the Royal Astronomical Society, besides holding membership in other scientific associations. His name will remain permanently connected with the astronomical history of the last fifty years.

Personally, he was wholly unpretentious and sociable, cordial and constant in friendship, and entertaining in conversation. His powers of intellect were creative rather than critical; in other words, he has left among those who knew him the remembrance not so much of mere talent as of positive genius.

# RELATIONS BETWEEN THE SPECTRA AND OTHER CHARACTERISTICS OF THE STARS.*

HENRY NORRIS RUSSELL.

Investigations into the nature of the stars must necessarily be very largely based upon the average characteristics of groups of stars selected in various ways,—as by brightness, proper motion, and the like. The publication within the last few years of a great wealth of accumulated observational material makes the compilation of such data an easy process; but some methods of grouping appear to bring out much more definite and interesting relations than others, and, of all the principles of division, that which separates the stars according to their spectral types has revealed the most remarkable differences, and those which most stimulate attempts at a theoretical explanation.

In the present discussion, I shall attempt to review very rapidly the principal results reached by other investigators, and shall then ask your indulgence for an account of certain researches in which I have been engaged during the past few years.

Thanks to the possibility of obtaining with the objective prism photographs of the spectra of hundreds of stars on a single plate, the number of stars whose spectra have been observed and classified now exceeds one hundred thousand, and probably as many more are within the reach of existing instruments. The vast majority of these spectra show only dark lines, indicating that absorption in the outer and least dense layers of the stellar atmospheres is the main cause of their production. Even if we could not identify a single line as arising from some known constituent of these atmospheres, we could nevertheless draw from a study of the spectra, considered merely as line-patterns, a conclusion of fundamental importance.

The spectra of the stars show remarkably few radical differences in type. More than ninety-nine per cent of them fall into one or other of the six great groups which, during the classic work of the Harvard College Observatory, were recognized as of fundamental importance,

* An address delivered before a joint meeting of the Astronomical and Astrophysical Society of America and Section A of the American Association for the Advancement of Science, at Atlanta, Georgia, December 30, 1913, with a few additions.

and received as designations, by the process of "survival of the fittest", the rather arbitrary series of letters B, A, F, G, K, and M. That there should be so few types is noteworthy; but much more remarkable is the fact that they form a continuous series. Every degree of gradation, for example, between the typical spectra denoted by B and A may be found in different stars, and the same is true to the end of the series, a fact recognized in the familiar decimal classification, in which B5, for example, denotes a spectrum half-way between the typical examples of B and A. This series is not merely continuous; it is *linear.* There exist indeed slight differences between the spectra of different stars of the same spectral class, such as A0; but these relate to minor details, which usually require a trained eye for their detection, while the difference between successive classes, such as A and F, are conspicuous to the novice. Almost all the stars of the small outstanding minority fall into three other classes, denoted by the letters O, N, and R. Of these O undoubtedly precedes B at the head of the series, while R and N, which grade into one another, come probably at its other end, though in this case the transition stages, if they exist, are not yet clearly worked out.

From these facts it may be concluded that the principal differences in stellar spectra, however they may originate, arise in the main from variations in a single physical condition in the stellar atmospheres. This follows at once from the linearity of the series. If the spectra depended, to a comparable degree, on two independently variable conditions, we should expect that we would be obliged to represent their relations, not by points on a line, but by points scattered over an area. The minor differences which are usually described as "peculiarities" may well represent the effects of other physical conditions than the controlling one.

The first great problem of stellar spectroscopy is the identification of this predominant cause of the spectral differences. The hypothesis which suggested itself immediately upon the first studies of stellar spectra was that the differences arose from variations in the chemical composition of the stars. Our knowledge of this composition is now very extensive. Almost every line in the spectra of all the principal classes can be produced in the laboratory, and the evidence so secured regarding the uniformity of nature is probably the most impressive in existence. The lines of certain elements are indeed characteristic of particular spectral classes; those of helium, for instance, appear only in Class B, and form its most distinctive characteristic. But negative conclusions are proverbially unsafe. The integrated spectrum of the Sun shows no evidence whatever of helium, but in that of the chromosphere it is exceedingly conspicuous. Were it not for the fact that

we are near this one star of Class G, and can study it in detail, we might have erroneously concluded that helium was confined to the "helium stars". There are other cogent arguments against this hypothesis. For example, the members of a star-cluster, which are all moving together, and presumably have a common origin, and even the physically connected components of many double stars, may have spectra of very different types, and it is very hard to see how, in such a case, all the helium and most of the hydrogen could have collected in one star, and practically all the metals in the other. A further argument—and to the speaker a very convincing one—is that it is almost unbelievable that differences of chemical composition should reduce to a function of a single variable, and give rise to the observed linear series of spectral types.

I need not detain you with the recital of the steps by which astrophysicists have become generally convinced that the main cause of the differences of the spectral classes is difference of temperature of the stellar atmospheres. There is time only to review some of the most important evidence which, converging from several quarters, affords apparently a secure basis for this belief.

The first argument is based upon the behavior of the spectral lines themselves. To appreciate its full force, one must familiarize himself with a multitude of details. A typical instance is that of the heavy bands in the region of longer wave-length, which are the most characteristic feature of spectra of Class M, appear faintly in Class K5, and are absent in Class K and all those higher in the series. Fowler has shown* that these bands are perfectly reproduced in the spectrum of the outer flame of an electric arc charged with some compound of titanium, while the spectrum of the core of the arc, though showing conspicuously the bright lines of titanium, does not contain the bands. Here we are evidently dealing with some compound,—perhaps titanium oxide,—whose vapor is present in the relatively cool flame of the arc, and emits a spectrum of the banded type characteristic of compounds, while in the hotter core it is dissociated, and only the lines of the metal are seen. There seems then to be no escape from the conclusion that the atmospheres of stars of Class M are cool enough to permit the existence of this compound, and hence cooler than the core of the arc, and that the temperature of its dissociation is approached in Class K5, and surpassed in Class K. In general, those metallic lines which are relatively strong in the spectra produced in the oxyhydrogen flame or the electric furnace are also strong in spectra of Classes M and K; the lines most prominent in Class G are the typical arc lines; and the rela-

* Proc. Roy. Soc. Vol. 72, pp. 219-225, 1904.

tively few metallic lines which persist into Classes A and B are those which appear exclusively, or with greatly enhanced intensity, in the spark spectra of the laboratory.

The second line of evidence is afforded by the distribution of intensity in the continuous background of the spectra, whose differences from type to type are obvious to the eye as differences in the color of the stars. This characteristic is fortunately capable of accurate measurement. For the brighter stars, spectro-photometric comparisons may be made with a terrestrial light-source whose energy curve is known, as has been done visually by Wilsing and Scheiner*, and photographically by Rosenberg†. Much fainter stars may be reached by the comparison of their brightness as measured visually, (or on isochromatic plates with a suitable color screen) and photographically on ordinary plates. The "color-index" so obtained, which expresses, in stellar magnitudes, the relative photographic brightness of stars of equal visual brightness, is found to be very intimately related to the spectral type,—the differences within each spectral class being hardly greater than the errors of observation. The results of King,‡ Parkhurst,¶ and Schwarzschild,‖ working with different instruments and on stars of very different brightness, are in excellent agreement, as is shown in Table I. The near approach to equality among the differences in color-index from class to class is very remarkable, when it is considered that these types were picked out somewhat arbitrarily according to the general appearance of the photographic spectra. The judgment of the Harvard observers in selecting the really important points of difference was evidently very good.

TABLE I

| Spectrum | Color-Index | | | Temperature |
|---|---|---|---|---|
| | King | Parkhurst | Schwarzschild | |
| B0 | —0.32 | | | 20000: |
| B5 | —0.17 | —0.21 | —0.20 | 14000 |
| A0 | 0.00 | 0.00 | 0.00 | 11000 |
| A5 | 0.19 | 0.23 | 0.20 | 9000 |
| F0 | 0.30 | 0.43 | 0.40 | 7500 |
| F5 | 0.52 | 0.65 | 0.60 | 6000 |
| G0 | 0.71 | 0.86 | 0.84 | 5000 |
| G5 | 0.90 | 1.07 | 1.10 | 4500 |
| K0 | 1.16 | 1.30 | 1.35 | 4200 |
| K5 | 1.62 | 1.51 | 1.80 | 3200 |
| M | 1.62 | 1.68 | | 3100 |
| N | | 2.5 | | 2300: |

* Potsdam Publications, Vol. 19, part 1.
† *A. N.* 4628, 1913.
‡ Harvard Annals, Vol. 59, p. 179.
¶ Astrophys. Jour. Vol. 36, p. 218, 1912.
‖ Göttingen Aktinometrie, Teil B. p. 19.

If the spectral sensitiveness of the plates used in such investigations has been determined, (as Parkhurst has done) it is possible to calculate the temperature at which a black body would emit light of the same color as that observed; and similar calculations can be made, with greater accuracy, from the spectro-photometric data. The last column of Table I gives the effective temperatures thus derived, (based mainly on the work of Wilsing and Scheiner). The absolute values of the temperatures here given may be considerably in error, especially at the top of the scale, (in fact, Rosenberg's work indicates a much greater range), but there can be no doubt about the relative order.

Of a third independent confirmation of the temperature hypothesis, based on the determination of the surface brightness of the stars, I shall have occasion to speak later.

It should be expressly stated that the "temperatures" here spoken of are the effective "black body" temperatures corresponding to the spectral distribution of the radiation. Unless the surfaces of the stars possess decided selective emissivity for certain wave-lengths, these effective temperatures should also indicate with tolerable accuracy the energy density of the flux of radiation which escapes from them. This tells us little about the temperature of the deeper regions; but it must be the main, if not the only, factor in determining the temperature of those outer and nearly transparent layers of the atmospheres in which the characteristic line absorption takes place. If we further assume, in accordance with Abbot's studies of the solar atmosphere,* that the absorption is nearly complete in so small a thickness of the atmosphere that wide variations in its depth and density would modify its total absorption but little, it becomes easy to see how the influence of its temperature, (which presumably determines the relative strengths of absorption in different lines) may predominate so greatly over that of all other factors in determining the spectral type.

We may now rapidly review some of the relations which have been brought to light between other characteristics of the stars and their spectral types. First, as regards the relative numbers of stars of the different classes, we have in Table II some results of counts made at Harvard.†

TABLE II

| Spectrum | O | B | A | F | G | K | M | N |
|---|---|---|---|---|---|---|---|---|
| Number above $3^m.25$ | 3 | 52 | 32 | 16 | 20 | 35 | 21 | 0 |
| Number above $6^m.25$ | 20 | 696 | 1885 | 720 | 609 | 1719 | 457 | 8 |
| Percentage in Galactic Region | 100 | 82 | 66 | 57 | 58 | 56 | 54 | 87 |

* Abbot, The Sun, p. 252, 1911.
† Harvard Annals, Vol. 64, p. 134.

Classes A and K make up more than half of all the stars brighter than $6^m.25$,—that is, of the stars visible to the naked eye. The remaining stars are divided fairly evenly among the other four principal classes, while only one star in 300 is of Class O, and only one in 800 of Class N. The relative proportions of the different classes are however different in different parts of the heavens, as is indicated by the last line of the table, which gives the percentage of stars of each class which lie in a belt covering one-half of the celestial sphere, and extending for 30° each side of the Milky Way. All the stars of Class O are close to the central line of the Galaxy, (except for a few in the Magellanic Clouds). The stars of Class B are very strongly concentrated in the galactic region; those of Class A are considerably so; those of the following classes very little, except in the case of Class N (for which the tabular percentage is derived, not from the eight brightest stars of this class alone, but from a much larger number of fainter ones).*

The relative proportions of the different classes vary also with the apparent brightness of the stars. Among the stars brighter than $3^m.25$, as the table shows, Class B has more representatives than any other, but the percentage of this type steadily diminishes as we pass to fainter stars. The percentage of stars of class A at first increases with diminishing visual brightness; but there is good reason to believe that, at least in regions remote from the Galaxy, the relative proportion of these too falls off rapidly in the neighborhood of the ninth magnitude;† and Fath's work on the integrated spectrum of the Milky Way‡ shows that even there, the bulk of the very faint stars which form the galactic clouds must be of Secchi's second type (F, G, or K).

Counts of the stars down to any given magnitude may however be very misleading unless we bear in mind the enormous preference which this method of observation gives to the stars of great actual luminosity, which can be seen afar off, and hence are being sought in a much greater volume of space than those of small luminosity. A difference of but five magnitudes in the real brightness of two groups of stars gives the brighter kind (if both are uniformly distributed in space) a thousand-fold better chance of getting into our catalogues;—and this example understates the actual conditions in some cases. Mere counts of stars need therefore to be supplemented by such knowledge as we can obtain concerning their distances.

Much information can be obtained from the average proper motions of the stars of the various classes, and still more by deriving their average parallaxes from the mean parallactic drift due to the motion

* Harvard Annals, Vol. 66, p. 213.
† Astronomical Journal, Vol. 26, p. 153, 1910.
‡ Astrophys. Jour. Vol. 36, pp. 362-367, 1912.

of the solar system in space. Studies of this character have been made by several investigators of the first rank. Their results, which are summarized in Table III, show certain apparent discrepancies, which however arise principally from differences in the methods according to which the various workers have selected the groups of stars for investigation.

TABLE III

| Spectrum | Mean Centennial Proper Motion | | | Mean Parallax | | | |
|---|---|---|---|---|---|---|---|
| | Kapteyn | Boss | % Rej. | Kapteyn | Boss | Campbell | % Rej. |
| | ″ | ″ | | ″ | ″ | ″ | |
| O | | 1.6 | 0 | | 0.004 | | |
| B | 2.6 | 2.4 | 0 | 0.007 | 0.007 | 0.006 | 0 |
| A | 5.8 | 4.6 | 3 | 0.010 | 0.010 | 0.016 | 3 |
| F | 14.5 | 7.7 | 28 | | 0.012 | 0.035 | 3 |
| G | 27.0 | 5.2 | 20 | 0.022 | 0.008 | 0.022 | 8 |
| K | 13.0 | 5.7 | 6 | | 0.010 | 0.015 | 9 |
| M | 5.9 | 5.0 | 6 | 0.011 | 0.008 | 0.011 | 3 |
| N | | 3.2 | | 0.000 | | | |

Kapteyn's data* represent the mean proper motions and parallaxes of all the stars of the fifth magnitude of each class, except for Class N, in which, to get enough stars, it was necessary to include faint objects, so that the average magnitude is here 8.3. His results show a conspicuous maximum of average proper motion and parallax for Class G, with a rapid fall on both sides of it. The stars of Class N would have to be brought about five times nearer to appear as bright as the others, but even then they would have the smallest mean parallax of all.

Boss,† in his investigation of the solar motion, had at his disposal very accurate proper motions of all the stars down to $5^m.7$, and about half as many more between this and the seventh magnitude. The average magnitude of his stars is therefore nearly the same as that of Kapteyn's. But, for very good reasons, he excluded from his main solution all stars with proper motions exceeding 20″ per century. The percentage of stars thus excluded (which differs greatly from class to class) is given in the fourth column of Table III. It is natural that this often drastic rejection of the large proper motions, and hence in general of the nearer stars, should greatly diminish his mean values. Among the classes in which the mean proper motion is small, the percentage of exclusion is also small, and the results are but little modified. But it is noteworthy that the exclusion of six per cent of the stars of

* Astrophys. Jour. Vol. 30, p. 295; Vol. 32, p. 91. 1909-10.

† Astronomical Journal, Vol. 26, pp. 187-201, 1911. The mean proper-motions of the few stars of Classes O and N which appear in Boss's Catalogue have been added by the writer.

Class K has reduced the mean proper motion in a greater ratio than that of 28 per cent of those of Class F, and also that the removal of one fifth of the stars of Class G decreases the mean for the remainder to less than one fifth of its initial value. It appears from these results that a large majority of the stars of Classes F, G, and K have nearly if not quite as small parallaxes and proper motions as those of Classes A and M, though they are not quite so remote as the stars of Class B. The large mean values obtained for all the stars of these classes are due to the presence of a relatively small proportion of near and apparently rapidly moving stars, of which the percentage decreases, but the mean proper motion and parallax increase, from F to K.

Campbell's results* are derived from a comparison of the radial velocities and proper motions of nearly 1200 stars, mostly brighter than the fifth magnitude, and averaging about a magnitude brighter than Boss's stars, which would lead us to expect that their mean parallaxes should be forty or fifty per cent greater. In his work "a few stars having proper motions abnormally large for their classes were omitted in accordance with definitely set limits" (which unfortunately are not described more specifically). The approximate percentage of exclusion is given in the last column of the table. It appears on inspection that the differences between Campbell's and Boss's results for stars of Classes A, K, and M arise mainly from the greater brightness of Campbell's stars; those for Classes F and G are due mainly to the different percentages of exclusion; and that the only significant difference is that Campbell's B-stars, though averaging much brighter to the eye than Boss's, have a slightly smaller mean parallax, and therefore must be, on the average, of greater real brightness.

Closely allied with these investigations is the determination of the mean peculiar velocity of the stars of each spectral class. The results of Boss and Campbell, reached almost simultaneously, and from quite independent data,—proper motions in one case and radial velocities in the other,—are in extraordinary agreement. The values found for the average component of motion in any arbitrary direction are, (in kilometers per second):

| Spectrum | B | A | F | G | K | M |
|---|---|---|---|---|---|---|
| Campbell | 6.5 | 10.5 | 14.4 | 15.9 | 16.8 | 17.1 |
| Boss | 6.3 | 10.2 | 16.2 | 18.6 | 15.1 | 17.1 |

The rapid increase of the mean velocity from B to F is very remarkable. The slow further gain from F to M would attract little attention if it were not in the same direction.

* Lick Observatory Bulletin, Vol. 6, p. 134, 1911.

It should here be added that the phenomenon known as preferential motion, or "star-streaming"—the excess of the average peculiar velocity of the stars in a certain direction above those in the perpendicular directions,—is almost absent in Class B, very conspicuous in Class A, and somewhat less so in the following classes, (being partially concealed by the greater average magnitude of the velocities).

Another notable difference between the various spectral classes may be found in the number of binary stars, both visual and spectroscopic, among them. We may distinguish two classes of visual double stars; binary stars for which orbits have been computed, (with periods rarely exceeding two centuries), and physical pairs, whose real connection is proved by common proper motion, but whose relative motions are slow, and periods long,—probably, often thousands of years. The counts of these two classes here given are from a list prepared in the course of my work, and include all stars for which the necessary data could be obtained, including many stars for which unpublished observations of spectra have been generously furnished me from Harvard. For the spectroscopic binaries, Campbell's counts have been taken from his Catalogue of 1910.* They include all the systems whose periods were then known, and are divided into two groups,—one including all whose periods are less than ten days, and also all those whose periods, though not exactly known, are described as short; the other all the known periods exceeding ten days, and those which, though not precisely determined, are known to be long

TABLE IV

| Spectrum | Visual Binaries | Physical Pairs | Spectroscopic Binaries | |
|---|---|---|---|---|
| | | | Short Period | Long Period |
| B | 0 | 52 | 33 | 15 |
| A | 14 | 152 | 15 | 14 |
| F | 33 | 115 | 11 | 9 |
| G | 24 | 74 | 8 | 14 |
| K | 12 | 62 | 0 | 13 |
| M | 0 | 11 | 0 | 2 |

It appears that, in Campbell's picturesque phrase, visual double stars of relatively short period "abhor" Classes B and M, the greatest number being of Class F, with G a good second. Among the physical pairs, of long period, the most favored class is A. Class B is abundantly represented, and Class M very sparingly.

The percentage of stars which are found to be spectroscopic binaries is very probably greater among Classes B and A than lower down the list. As time goes on, indeed, more and more of the stars of these

* Lick Observatory Bulletin, Vol. 6, p. 38, 1910.

"later" types are found to be spectroscopically double but of long period, but among these classes the detection of such systems, where the range of velocity is small, is much easier than among the stars of the first type, whose lines are diffuse. In any case it is certain that short periods are almost confined to Classes B, A, and F, and are especially abundant in the first of these. The few short period stars of Class G which appear in the table are all Cepheid variables, most of which were selected for observation on this account, and would not otherwise have got into the list.

Finally, we may note that, among variable stars, those of the eclipsing type, such as Algol or Beta Lyrae, are for the most part of Classes A and B, though there are a number of Classes F and G, and one at least of Class K; that the Cepheid variables are almost all of Classes F and G, with a few of A and K; and that almost all the irregular variables, and all the variables of long period, are of Classes M or N: Stars of Class M whose spectra show bright hydrogen lines are without exception variable, and almost all the stars of Class N are also subject to changes in brightness.

Having thus made a rapid survey of the general field, I will now ask your attention in greater detail to certain relations which have been the more special objects of my study.

Let us begin with the relations between the spectra and the real brightness of the stars. These have been discussed by many investigators,—notably by Kapteyn and Hertzsprung,—and many of the facts which will be brought before you are not new; but the observational material here presented is, I believe, much more extensive than has hitherto been assembled. We can only determine the real brightness of a star when we know its distance; but the recent accumulation of direct measures of parallax, and the discovery of several moving clusters of stars whose distances can be determined, put at our disposal far more extensive data than were available a few years ago.

Figure 1 shows graphically the results derived from all the direct measures of parallax available in the spring of 1913 (when the diagram was constructed). The spectral class appears as the horizontal coördinate, while the vertical one is the absolute magnitude, according to Kapteyn's definition,—that is, the visual magnitude which each star would appear to have if it should be brought up to a standard distance, corresponding to a parallax of 0″.1 (no account being taken of any possible absorption of light in space.) The absolute magnitude −5, at the top of the diagram, corresponds to a luminosity 7500 times that of the Sun, whose absolute magnitude is 4.7. The absolute magnitude 14, at the bottom, corresponds to $\frac{1}{5000}$ of the Sun's luminosity. The larger dots denote the stars for which the computed probable error of the

parallax is less than 42 per cent of the parallax itself, so that the probable error of the resulting absolute magnitude is less than $\pm 1^{m}.0$.

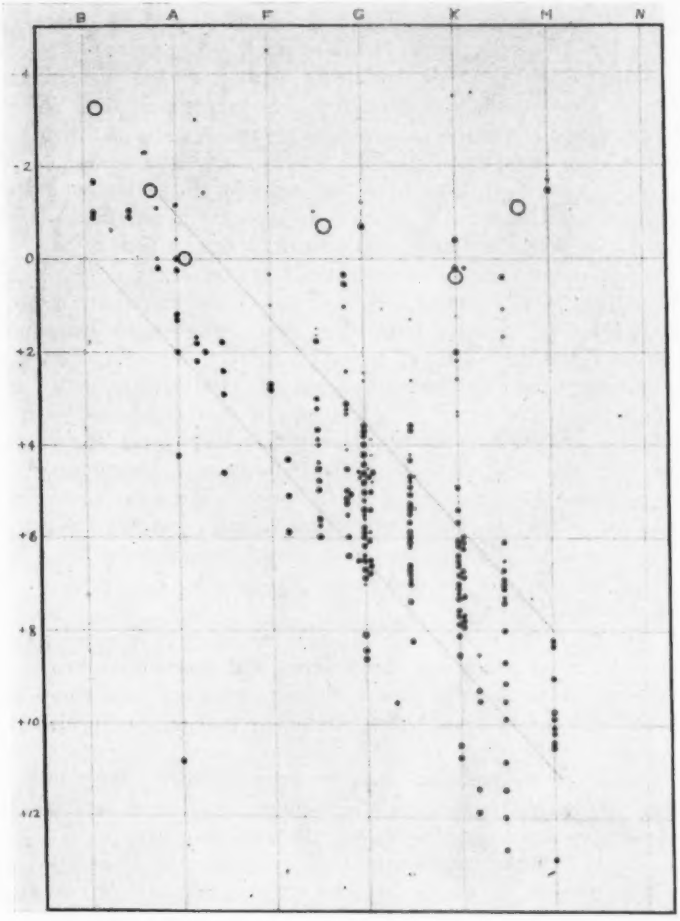



FIGURE 1.

This is a fairly tolerant criterion for a "good parallax", and the small dots, representing the results derived from the poor parallaxes, should hardly be used as a basis for any argument. The solid black dots represent stars whose parallaxes depend on the mean of two or more determinations; the open circles, those observed but once. In the latter case, only the results of those observers whose work appears to

be nearly free from systematic error have been included, and in all cases the observed parallaxes have been corrected for the probable mean parallax of the comparison stars to which they were referred. The large open circles in the upper part of the diagram represent mean results for numerous bright stars of small proper motion (about 120 altogether) whose observed parallaxes hardly exceed their probable errors. In this case the best thing to do is to take means of the observed parallaxes and magnitudes for suitable groups of stars, and then calculate the absolute magnitudes of the typical stars thus defined. These will not exactly correspond to the mean of the individual absolute magnitudes, which we could obtain if we knew all the parallaxes exactly, but they are pretty certainly good enough for our purpose.

Upon studying Figure 1, several things can be observed.

1. All the white stars, of Classes B and A, are bright, far exceeding the Sun; and all the very faint stars,—for example, those less than $\frac{1}{30}$ as bright as the Sun,—are red, and of Classes K and M. We may make this statement more specific by saying, as Hertzsprung does,* that there is a certain l mit of brightness for each spectral class, below which stars of this class are very rare, if they occur at all. Our diagram shows that this limit varies by rather more than two magnitudes from class to class. The single apparent exception is the faint double companion to $o^2$ Eridani, concerning whose parallax and brightness there can be no doubt, but whose spectrum, though apparently of Class A, is rendered very difficult of observation by the proximity of its far brighter primary.

2. On the other hand, there are many red stars of great brightness, such as Arcturus, Aldebaran and Antares, and these are as bright, on the average, as the stars of Class A, though probably fainter than those of Class B. Direct measures of parallax are unsuited to furnish even an estimate of the upper limit of brightness to which these stars attain, but it is clear that some stars of all the principal classes must be very bright. The range of actual brightness among the stars of each spectral class therefore increases steadily with increasing redness.

3. But it is further noteworthy that all the stars of Classes K5 and M which appear on our diagram are either very bright or very faint. There are none comparable with the Sun in brightness. We must be very careful here not to be misled by the results of the methods of selection employed by observers of stellar parallax. They have for the most part observed either the stars which appear brightest to the naked eye or stars of large proper motion. In the first case, the method of selection gives an enormous preference to stars of great luminosity, and, in

* *A. N.* 4422, 1910.

the second, to the nearest and most rapidly moving stars, without much regard to their actual brightness. It is not surprising, therefore, that the stars picked out in the first way (and represented by the large circles in Figure 1) should be much brighter than those picked out by the second method, (and represented by the smaller dots). But if we consider the lower half of the diagram alone, in which all the stars have been picked out for proper-motion, we find that there are no very faint stars of Class G, and no relatively bright ones of Class M. As these stars were selected for observation entirely without consideration of their spectra, (most of which were then unknown) it seems clear that this difference, at least, is real, and that there is a real lack of red stars comparable in brightness to the Sun, relatively to the number of those 100 times fainter.

The appearance of Figure 1 therefore suggests the hypothesis that, if we could put on it some thousands of stars, instead of the 300 now available, and plot their absolute magnitudes without uncertainty arising from observational error, we would find the points representing them clustered principally close to two lines, one descending sharply along the diagonal, from B to M, the other starting also at B, but running almost horizontally. The individual points, though thickest near the diagonal line, would scatter above and below it to a vertical distance corresponding to at least two magnitudes, and similarly would be thickest near the horizontal line, but scatter above and below it to a distance which cannot so far be definitely specified, so that there would be two fairly broad bands in which most of the points lay. For Classes A and F, these two zones would overlap, while their outliers would still intermingle in Class G, and probably even in Class K. There would however be left a triangular space between the two zones, at the right-hand edge of the diagram, where very few, if any, points appeared; and the lower left-hand corner would be still more nearly vacant.

We may express this hypothesis in another form by saying that there are two great classes of stars,—the one of great brightness, (averaging perhaps a hundred times as bright as the Sun) and varying very little in brightness from one class of spectrum to another; the other of smaller brightness, which falls off very rapidly with increasing redness. These two classes of stars were first noticed by Hertzsprung,* who has applied to them the excellent names of *giant* and *dwarf* stars. The two groups, on account of the considerable internal differences in each, are only distinctly separated among the stars of Class K or redder. In Class F they are partially, and in Class A thoroughly intermingled, while the stars of Class B may be regarded equally well as belonging to either series.

* Zeitschrift fur Wissenschaftliche Photographie, Vol. 3, p. 442, 1905.

proper motions that their inclusion more than doubles the mean proper motion, and presumably also the mean parallax of the whole, as shown by Kapteyn's figures in Table III. For Class G, the dwarf stars average much brighter, and a much greater number of them are visible to the naked eye. These have large parallaxes and proper motions, and raise the average for all the stars of this class to greater values than for any other. But Boss's rigorous limitation to small proper motions practically weeds them all out, leaving giant stars once more. Campbell's less drastic procedure admits only the nearer of the dwarfs, (to be precise, those with the larger proper motions) and his result lies about half way between the others, In the case of Class F, the dwarf stars are still brighter,—intermingling, in fact, with the giants. We can therefore see them farther off, and we get more of them in our catalogues, in proportion to the giants, than in any other class. Their mean parallax is however smaller than for the dwarfs of Classes G and K, and hence the mean proper motion and parallax of all the stars of this class is less than for Class G. Campbell's criterion here excludes very few stars, and even Boss's admits a good many of the remoter and slower moving dwarfs, causing his mean parallax and proper motion to be considerably greater for this class than for any other.

It should finally be added that Kapteyn's discussion shows that the stars of class N are exceedingly bright, possibly surpassing any of the other giant stars.

We are now in a position to define more precisely the brightness of a typical giant or dwarf star of a given class of spectrum, and also to obtain a measure of the degree of divergence of the individual stars from this typical brightness. Taking first the stars of class B and the dwarf stars of the other classes, we find for the mean absolute magnitudes of all the stars of each class, the following values.

TABLE V

MEAN ABSOLUTE MAGNITUDES

| Spectrum | Stars of Measured Parallax | | | | Stars in Clusters | | | |
|---|---|---|---|---|---|---|---|---|
| | No. | Abs. Mag. | Formula | O—C | No. | Abs. Mag. | Formula | O—C |
| B2 | ... | ... | ... | ... | 21 | —1.2 | —1.1 | —0.1 |
| B8 | ... | ... | ... | ... | 8 | +0.3 | +0.2 | +0.1 |
| A0 | 6 | +1.4 | +1.4 | 0.0 | 13 | 0.5 | 0.6 | —0.1 |
| A4 | 7 | 2.5 | 2.3 | +0.2 | 26 | 1.7 | 1.5 | +0.2 |
| F0 | ... | ... | ... | ... | 15 | 2.4 | 2.7 | —0.3 |
| F1 | 5 | 4.2 | 3.7 | +0.5 | ... | ... | ... | ... |
| F3 | ... | ... | ... | ... | 7 | 3.3 | 3.3 | 0.0 |
| F5 | 9 | 4.3 | 4.5 | —0.2 | ... | ... | ... | ... |
| F8 | 8 | 5.1 | 5.2 | —0.1 | 5 | 4.2 | 4.4 | —0.2 |
| G0 | 29 | 5.7 | 5.6 | +0.1 | 18 | 5.0 | 4.8 | +0.2 |
| G5 | 19 | 5.7 | 6.6 | —0.9 | 9 | 5.1 | 5.8 | —0.7 |
| K0 | 28 | 7.1 | 7.7 | —0.6 | 9 | 6.4 | 6.9 | —0.5 |
| K4 | 19 | 9.2 | 8.6 | +0.6 | 7 | +7.0 | +7.7 | (—0.7) |
| Ma | 10 | +9.9 | +9.8 | +0.1 | ... | ... | ... | ... |

The rate of decrease of brightness with increasing redness is very nearly the same for the stars with directly measured parallaxes and the stars in clusters, but the latter appear, with remarkable consistency, to be about $0^m.8$ brighter than the former. This seems at first sight very puzzling, but it is undoubtedly due to the way in which the stars observed for parallax were selected. Most observers, in preparing their working lists, have included mainly those stars which were brighter than a given magnitude, and had proper motions exceeding some definite limit. Of the stars above this limiting magnitude, those of greater actual luminosity will be, on the average, farther away, and have smaller proper motions, than those of small luminosity, and selection by proper motion favors the latter. The limitation of our present lists to stars whose parallaxes have been determined with a probable error not exceeding 42 per cent of their own amounts, though necessary to diminish the effects of casual errors of observation, works in the same direction, for, among the stars of any given visual magnitude, those of greatest luminosity have the smallest parallaxes, and are least likely to pass the test. The difference shown in our table need not therefore alarm us, but it is clear that the stars in clusters, rather than the others, should be taken as typical of the dwarf stars as a whole. For both sets of stars the absolute magnitude appears to be very nearly a linear function of the spectral class, (if B is regarded as 1, A as 2, &c). The columns headed "Formula" in Table V give the values calculated from the expressions $M = 1^m.4 + 2^m.1$ (Sp.$-$A) for the stars of directly measured parallax, and $M = 0^m.6 + 2^m.1$ (Sp.—A) for the stars in clusters. The residuals from these empirical formulae, for the mean absolute magnitudes of the observed stars of different classes, average $\pm 0^m.33$ in the first case, and $\pm 0^m.29$ in the second. They appear to be accidental in character, though in some cases, (notably in class G5), the residuals for the stars of the two sets are similar in sign and magnitude. The large negative residuals for Classes K and K5 in the clusters arise from the fact that in the Hyades, which contribute most of these stars, only the brighter ones have had their proper motions determined, and get into our lists,—as is clear from examination of Figure 2.

Among the dwarf stars, therefore, a typical star of any spectral class is about seven times fainter than one of the preceding class, and seven times brighter than one of the following class.

The giant stars of all the spectral classes appear to be of about the same mean brightness,—averaging a little above absolute magnitude zero, that is, about a hundred times as bright as the Sun. Since the stars of this series which appear in Figure 2 have been selected by apparent brightness, which gives a strong preference to those of the greatest luminosity, the average brightness, of all the giant stars in a

given region of space must be less than this,—perhaps considerably so.

By tabulating the residual differences between the absolute magnitudes of the individual dwarf stars and the values given by the formulae just described, we find that the average difference, regardless of sign, for the stars of measured parallax is $\pm 0^m.88$ for spectra A to F8, $\pm 1^m.02$ for spectra G and G5, and $\pm 1^m.15$ for K and M. For the stars in clusters the average differences are $\pm 0^m.70$ for spectra B0 to B9 $\pm 0^m.66$ for A and A5, $\pm 0^m.56$ for spectra F to F8, and $\pm 0^m.80$ for G and G5.

These differences are larger for the stars of measured parallax than for the others, (probably on account of the greater average uncertainty of the individual parallaxes and spectra in this case) but show no marked systematic variation with the class of spectrum. Their distribution follows very approximately the law of accidental errors, as is shown by Table VI, in which the observed numbers lying between certain limits are compared with those given by this law.

TABLE VI

DISTRIBUTION OF DIFFERENCES FROM THE TYPICAL ABSOLUTE MAGNITUDES

| Stars with Measured Parallax; | | | Stars in Clusters; | | |
|---|---|---|---|---|---|
| Limits | Observed | Theory | Limits | Observed | Theory |
| $\pm 0^m.0$ to $\pm 0^m.8$ | 65 | 61 | $\pm 0^m.0$ to $\pm 0^m.5$ | 59 | 58 |
| $\pm 0.8$ to $\pm 1.6$ | 41 | 44 | $\pm 0.5$ to $\pm 1.0$ | 42 | 42 |
| $\pm 1.6$ to $\pm 2.4$ | 21 | 23 | $\pm 1.0$ to $\pm 1.5$ | 21 | 24 |
| $\pm 2.4$ to $\pm 3.2$ | 10 | 9 | $\pm 1.5$ to $\pm 2.0$ | 10 | 8 |
| $\pm 3.2$ to $\pm 4.0$ | 3 | 3 | $\pm 2.0$ to $\pm 2.5$ | 4 | 4 |

The theoretical distribution for the stars in clusters corresponds to a probable error of $\pm 0^m.61$, and that for the others to one of $\pm 0^m.94$. Correction for the known influence of uncertainties of the parallaxes and spectra would reduce the latter to about $\pm 0^m.75$. It appears therefore that the absolute magnitude of a dwarf star can be predicted with surprising accuracy from a mere knowledge of its spectrum. Half of all the dwarf stars are not more than twice as bright or as faint as the typical stars of their spectral classes. The corresponding uncertainty in the estimated parallax would be about one-third of its amount.

The parallaxes of the giant stars are so small, in comparison with the errors of even the best present methods of observation, that direct observations are not well adapted to determine to what degree they differ in brightness among themselves. An indirect method of determining this is however practicable, among those classes in which all the naked-eye stars are giants, by comparing the parallactic motions of those stars whose proper motions at right angles to the direction of the parallactic drift are large and small. A discussion by this method of the typical case of Class M, (the details of which will be given else-

where), shows that, if the distribution of the absolute magnitudes of these stars also follows the "law of errors," the probable error corresponding to it is approximately $\pm 0^m.6$ —almost exactly the same as has already been found for the dwarf stars. The mean absolute magnitude of all the stars of this class which are visible to the naked eye is $-0.5$ and that of all the stars in a given region of space is $+0.6$. This method can hardly be applied to the naked-eye stars of the other spectral classes, (unless some way can be devised for weeding out the dwarf stars from among the giants); but it seems probable that they do not differ greatly from the stars of Classes B and M as regards the degree of their similarity to one another in brightness. With such a probable error of distribution of the absolute magnitudes as has here been derived, the giant and dwarf stars would overlap perceptibly in Class G, be just separated in Class K, and widely so in Class M, as the observational data indicate.

The questions now arise:—

What differences in their nature or constitution give rise to the differences in brightness between the giant and dwarf stars, and why should these differences show such a systematic increase with increasing redness, or "advancing" spectral type?

We must evidently attack the first of these questions before the second. The absolute magnitude (or the actual luminosity) of a star may be expressed as a function of three physically independent quantities,—its mass, its density, and its surface brightness. Great mass small density, and high surface brightness make for high luminosity, and the giant stars must possess at least one of these characteristics in a marked degree, while the dwarf stars must show one or more of the opposite attributes.

A good deal of information is available concerning all these characteristics of the stars. The masses of a considerable number of visual and spectroscopic binaries are known with tolerable accuracy, the densities of a larger number of eclipsing variable stars have recently been worked out; and the recent investigations on stellar temperatures lead directly to estimates of the relative surface brightness of the different spectral classes, (subject, of course, to the uncertainty whether the stars really radiate like black bodies, as they are assumed to do). We will take these matters up in order.

First, as regards the masses of the stars, we are confined to the study of binary systems, which may or may not be similar in mass to the other stars. There appears however to be no present evidence at all that they are different from the other stars, and in what follows we will assume them to be typical of the stars as a whole.

The most conspicuous thing about those stellar masses which have been determined with any approach to accuracy is their remarkable similarity. While the range in the known luminosities of the stars exceeds a million-fold, and that in the well-determined densities is nearly as great, the range in the masses so far investigated is only about fifty-fold. The greatest known masses are those of the components of the spectroscopic binary and eclipsing variable V Puppis, which equal nineteen times that of the Sun; the smallest masses concerning which we have any reliable knowledge belong to the faint components of Zeta Herculis and Procyon and are from one-third to one-fourth of the Sun's mass. These are exceptional values, and the components of most binary systems are more nearly similar to the Sun in mass.

There appears, from the rather scanty evidence at present available, to be some correlation between mass and luminosity. Those stars which are known to be of small mass (say less than half the Sun's) are all considerably fainter than the sun. On the other hand, Ludendorff* has shown conclusively that the average mass of the spectroscopic binaries of spectrum B (which are all of very great luminosity) is three times as great as that of the spectroscopic binaries of other spectral types, and may exceed ten times that of the Sun. Further evidence in favor of this view is found in the fact that the components of a binary, when equal in brightness, are nearly equal in mass, while in unequal pairs the brighter star is almost (if not quite) always the more massive, but the ratio of the masses very rarely exceeds 3:1, even when one component is hundreds of times as bright as the other. Very large masses (such as 100 times the Sun's mass) do not appear, though they would certainly be detected among the spectroscopic binaries, if they existed. It is equally remarkable that there is no reliable evidence that any visible star has a mass as small as one-tenth that of the Sun. The apparent exceptions which may be found in the literature of the subject may be shown to arise from faulty determinations of parallax, arbitrary estimates of quantities unobtainable by observation, (such as the ratio of the densities of the two components of Algol), and even numerical mistakes.

[*To be Continued.*]

* *A. N.* 4520, 1911.

# MONTHLY REPORT ON MARS.—No. 5.

WILLIAM H. PICKERING.

## Aristillus.

The atmospheric conditions in Jamaica were unfavorable during the months of February and March, owing to the successive storms and cold waves in the north, producing so-called "northers" here. These consist of cold winds which bring bad seeing. Nevertheless, at least one interesting observation was made. On the nights of February 18 and 24 the "double canal effect" was seen faintly in the canals Thoth and Nepenthes. The reader will note that the writer does not claim that these canals were really double, merely that this much-discussed appearance was visible.

The effect has been seen at one time or another by practically everyone who has studied the planet at length, under favorable atmospheric conditions. It may therefore be conceded to exist at certain times. The question which has been at issue from the first, however, is not as to the appearance itself, but rather as to the explanation of it.

Before discussing the matter at length we will first recall some of the facts hitherto published regarding it. Schiaparelli claimed that the effect was at its maximum three of our months before the summer solstice of the northern hemisphere of Mars, and again five months after it. These dates would correspond to longitudes $\odot = 50°$ and $\odot = 162°$, which it will be noticed are about one-third of a Martian year apart. The corresponding Martian dates are May 9 and August 31. The corresponding heliocentric longitudes are 138° and 250°. Consequently the planet is most favorably situated for observing the duplication at oppositions occurring near February 7 and June 1. The planet would be nearer us on the latter date.

Lowell claims, Bulletin No. 15, that only one-quarter of the canals are ever double, and that this quarter is double all the time. The canals are so indistinct at certain of the Martian seasons, however, that the duplication is invisible. It is particularly conspicuous at the seasons noted by Schiaparelli, when the canals are most clearly seen. Often one component of the double is more conspicuous than the other, therefore the canal may appear both single and double on successive evenings or on the same evening to two different observers.

This year longitude $\odot = 50°$ occurred on the terrestrial date of March 20. The planet was then rather remote, but the latter part of February was evidently a very good time to see the effect. The diameter of the planet on the two dates on which the duplication was recorded was 11″.0 and 10″.4. Especial care was taken to draw the breadth as accurately as possible on the second date, and it was found to be just one-twentieth of the diameter of the planet, 210 miles, 5°.7, or 0″.52. This was the extreme breadth, but assuming the breadth of each component equal to that of the space between them, this reduces to 140 miles, 3°.8, or 0″.34 from middle to middle. Lowell states that the breadth of the components is only one third of the intermediate space, which would make the distance between their middles 4.6° or 0″.42.

Thoth was a very conspicuous canal at the time the observations were made, one of the three most conspicuous upon the disk. My attention was drawn to it particularly because of a drawing sent to me by Professor Lowell, on which it was represented as double. In the above mentioned Bulletin he divides the double canals into two classes, those whose breadth exceed 5°.5, and those narrower. Only two specimens of the wider class were observed by him in 1903, and one of those he states was doubtful. These wide doubles he says are rare. It will be noticed that the canals observed here are but little narrower than this wider class.

Now as to the explanation. The canal may really have been double, since the observed separation is quite within the power of an 11-inch aperture. It was observed with magnifications both of 330 and 660 diameters, but the former was thought the better for the purpose, seeing 10 and 8. On the other hand, my impression recorded at the time was that the canal was not really double, but that the effect observed was due to contrast between the dark edges of the canal and the bright background on which it was situated, which made its interior appear less dark. It was far more difficult to detect than a double star of the same distance apart, because the contrast with the background was so much less, and also because the shape of the star calls one's attention to it at once.

In any case it was at practically the limit of steady vision, and anything narrower would have been seen only by glimpses, and would have appeared to me of very doubtful reality. Lowell gives the width of this same canal in his circular as 3°.0, and of some as only 2°.3, or but half as wide as our figure. Indeed he says "The doubles, like all delicate detail, appear not continuously, but by flashes of revelation according as the atmospheric waves permit of passage undisturbed." The planet was of about the same size when he observed it, but his aperture, which he varies, as usually employed is about half as large again as the writer's.

How then shall we decide whether the canal is really double, or only a contrast effect or something of that sort. Suppose that an observer should see what appeared to be two long narrow dark lines upon the moon, at a distance of 2″ apart, and should see them clearly at every lunation, he would say unhesitatingly, and perfectly properly, that the appearance was really due to two separate dark lines. Probably he would do the same if they were only 1″ apart. But how about one-half or one-quarter second? Professor Lowell says he is satisfied that they are really two distinct lines, but the writer is not quite so certain about it.

If one-quarter of the canals on Mars are really constructed as parallel pairs, it would at first seem almost certain that they must be artificial. But a little difficulty here arises. It so happens that we see the same thing upon the moon, and oddly enough, if they are real, at just about the same angular distance apart. Now we cannot believe that any structure visible upon the moon is artificial. That would seem to be really asking too much. But the lunar doubles are quite as easily seen as those on Mars, and the writer thinks that one or two of them are clearly more so. Moreover they have the great advantage that they are equally well seen every month of the year, and that lunar meteorological conditions never interfere with them.

The most conspicuous lunar double canal is connected with the crater Aristillus. Sunrise occurs on Aristillus at colongitude 1°, noon at 91°, and sunset at 181°. As soon as the shadow leaves the interior, at colongitude 27°, a dark crack is observed running along the northwestern edge of the floor. From a shaded region near this crack, and which later joins it, a broad dark stream apparently ascends the inner wall to another shaded region half way to the top. This region sends a narrower dark stream up to the crater rim. At colongitude 52° the outside of the crater, and the *mare* to the northwest of it begin to darken appreciably, much as in the case of Eratosthenes, Harvard Annals **53**, 75. By colongitude 66° part of the outer region is as dark as the stream itself, and by 103° surpasses it. It remains dark for a few days longer, but fades out and almost disappears before sunset.

In the meantime the double canal ascends the inner wall of the crater within the shaded region. The earliest drawing made of it is in colongitude 27°, and it lasts until some time after 35°. The space between the canals then fills up, and the canal itself appears single and very wide and dark, until towards colongitude 108°, or a little after full moon. It then appears double a second time until colongitude 153°, after which it is again single, but gradually fades out, and is quite invisible before sunset. The duplication is seen to best advantage at the time of its two appearances. Near its origin on the floor it seems to be

very narrow. See Figure 1. It remains so until half-way up the wall, when it broadens slightly, but still remains a close double till it reaches the crater rim. From thence down to the outer plain the components diverge and are easily separated.

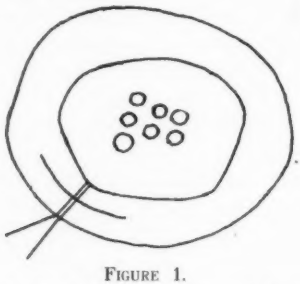


FIGURE 1.
DOUBLE CANAL IN THE LUNAR CRATER ARISTILLUS

On the inner crater wall the mean of four measures of the separation seeing 8 to 12, is 0.022 of the diameter of the crater. At mean distance the latter measures 28″, hence the mean width of the double is 0″.51. Similar doubles occur within Archimedes and Autolycus, the three doubles having nearly the same position angle. Another one occurs on the inner wall of Plato, also on the western side. One has been suspected in Werner, again on the western side, and other ones within several other craters. The doubles seem generally to be associated, as in the case of Aristillus, with areas which darken at noon and fade out before sunset. Single canals of the same general character are of much more frequent occurance, notably in the small brilliant snow craterlets of the type of Mösting A.

Of the various lunar doubles which the writer has recorded, Aristillus is the only one where the canal is continued on the outside by a diverging pair. It also appears to be slightly the widest, though there is not much choice between several of them. It seems therefore to be the best one to study. Since there are clearly two canals on the outside of the crater, the writer is inclined to believe that the double appearance on the inside also represents a real pair. To corroborate this view he has written to several of his correspondents who have adequate facilities for the study of the phenomenon, and hopes to receive answers from some of them in time to appear in his next Monthly Report.

In case their judgment agrees with his, it would seem likely that the close doubles detected in the other craters are also real. But if double canals form upon the moon, leading to regions which later darken as the sun rises higher upon them, and if the same appearance is visible

upon Mars, then it would seem likely that both cases are due to the same cause, and if one canal is really double, the other probably is so also. The lunar doubles like the Martian counterparts appear absolutely straight, uniform, and parallel, but since both are so near the limit of visibility, the writer does not feel that there is any satisfactory evidence that they are not so in fact, although there is of course no evidence that they are not.

We must note that there are three quite distinct questions connected with the double canal phenomena, which should not be confused. They are: (*a*) Do the canals sometimes appear double? (*b*) Are they really double? (*c*) Are the Martian canals artificial? Our answer to the first question depends largely on how we define the phrase "appear double." If we mean do they appear as distinctly double as a double star whose components are at a distance of 1″, the answer is certainly no. If we mean do they appear as clearly double as a star whose components are at a distance of one quarter of a second, that is a different question, and the writer would answer yes. The double effect has been seen by Schiaparelli, Perrotin, Lowell, Jarry Desloges, Douglass, Antoniadi, and a number of others. Allowing a reasonable latitude to our definition of the phrase, we may therefore answer the first question unhesitatingly in the affirmative.

As to the second question there is a difference of opinion, the first four observers replying in the affirmative, and the last two in the negative. If the writer had seen only Mars he would certainly have thrown in his lot with the last two but having seen and studied the lunar doubles, he rather favors the affirmative side, but will be glad to hear the views of some of his correspondents before expressing a definite opinion.

Unlike the first two questions, which can only be properly decided by the observers themselves, the third may be considered open to general discussion, where one man's opinion is as good as another's. If the canals should prove to be really double, and if they had been seen only on Mars, the writer would, with only a little hesitation, have declared them to be artificial. It is difficult to understand how such uniform structures could be created and maintained, without artificial aid and constant interference with the normal processes of nature. To find them on the Moon however, while it enables us to answer the second question more readily in the affirmative, makes the third much more difficult.

What we actually see on the Moon is a volcanic crack upon the crater floor, which may perhaps give out steam, and is connected by the canal with an outside area which in a few days darkens conspicuously, and fades just before sunset. Since the double canal is seen to best advant-

age about full moon, it cannot be merely a pair of straight cracks. The two canals are not over 1000 feet in breadth, and may not be over 500. They are about 2000 feet from middle to middle, and are parallel for nine miles, in which distance they ascend nearly 8000 feet over the rim of the crater. They then diverge, and descend some 3000 feet in three more miles. After that they travel eight miles more, on a nearly level plain before they are finally lost to sight. Their total length is therefore about 20 miles, the northern canal being practically straight all the way, and the other consisting of two straight sections. On the northern side of the crater there is a triangular area containing, and associated with, a number of short straight parallel dark lines, which are quite far enough apart to be seen distinctly. They are best observed soon after full moon.

An examination of the writer's photographic lunar Atlas, H. A. **51**, will show the regions of the two canals well developed at lunar noon, in plates 7C and 9C, while it has almost completely faded out towards sunset in plates 7E and 9E. The canals themselves are of course too delicate to show in the photograph.

Turning now to other matters. In our last Report it was shown that on two occasions at least, shortly after the vernal equinox of each hemisphere, a sharply bounded dark blue region suddenly developed at the northern extremity of the Syrtis major, and was connected, temporarily in each case, with the melting polar cap, by two canals. It appeared that it would be of interest to determine if there was any evidence that similar phenomena had occurred at other oppositions, at the same season of the Martian year. The available Martian literature at the writer's disposal was ransacked with the following results:—

1890. A record book of unpublished observations, made in Cambridge, showed that on August 8 a sharply defined dark blue area had developed in the Syrtis major. This had not been detected two days earlier, although seen under very favorable conditions. No canals were recorded. Interval after the vernal equinox 1.1 terrestrial months.

1892. The observations made this year are described in the last report. A sharply bounded dark blue area was formed about July 15 connected with the southern polar cap by two canals. Interval after the vernal equinox 1.8 months.

1894. The planet was not well situated to observe the phenomenon this year. If the marsh in the Syrtis was flooded, it probably occurred shortly before the telescope at Flagstaff was erected.

1896. Three drawings in the Annals Lowell Obs. **2**, Plates 21, 19, and 32 made February 19, 21, and 23, 1897 show the dark area sharply bounded, and connected with the north polar regions by two well marked canals. No statement is made regarding the color. Interval

after the vernal equinox 1.8 months. In the Memoirs B.A.A. **6**, Part 3, 91 it is stated that Molesworth describing this area says "that the northern end [of the Syrtis] was seen broadened out into an exceedingly dark diamond-shaped spot." He gives its color as a "distinct greenish blue tinge." Unfortunately the date of these two observations is not given.

1899. Annals Lowell Observatory **3** App. 22, 18, Two drawings made January 4 and 5 show the dark area sharply bounded and connected by only one canal with the north polar cap. No statement is made as to its color. Interval 2.0 months after vernal equinox. Another drawing made September 17, 1898 also shows the dark area sharply bounded, but this seems to be unusual, except immediately after the equinoxes.

1901. Annals Lowell Observatory **3** App. 51, 50. Two drawings made November 13, 1900 and January 23, 1901, 1.7 months and again 4.0 months after the equinox, show the sharply defined dark are in the Syrtis connected in the northern polar cap by two canals, in much the same manner as it appeared this last January. No statement is made regarding the color.

1903, 1905. The planet was not well situated for observation immediately after the equinox at these two oppositions.

1907. In Memoirs B.A.A. **17** Part 3, 97 it is stated that the Syrtis was very dark July 7 and 8, and again July 27, or 1.1 and 1.8 months after the equinox, being of a much lighter tint before and after these dates. Only one canal is clearly shown connecting it with the south polar cap. No statement is made regarding its color.

1909. The planet was not well situated for observation.

1911. The writer possesses no report of this opposition.

1914. The dark region was sharply defined and of a blue color on January 17, 1.0 months after the equinox. It was connected with the northern polar cap by two canals, as shown in our last Report.

While the reports of the observations made at these various oppositions do not generally give sufficient data to enable us to determine definitely whether the marsh in the Syrtis was temporarily flooded by the melting snow cap after each vernal equinox or not, yet in the seven cases which it has been possible to study, the evidence, based on the darkness and sharply defined character of the marsh, indicates that something of the sort occurred, and also that both the time required for the flooding, and the time during which the flooded condition existed were of comparatively short duration. At some oppositions it would seem probable that more than one flood occurred. Doubtless in several cases the main flood came at a time when it was not visible from either Europe or America, but only from the other side of the world. It is to

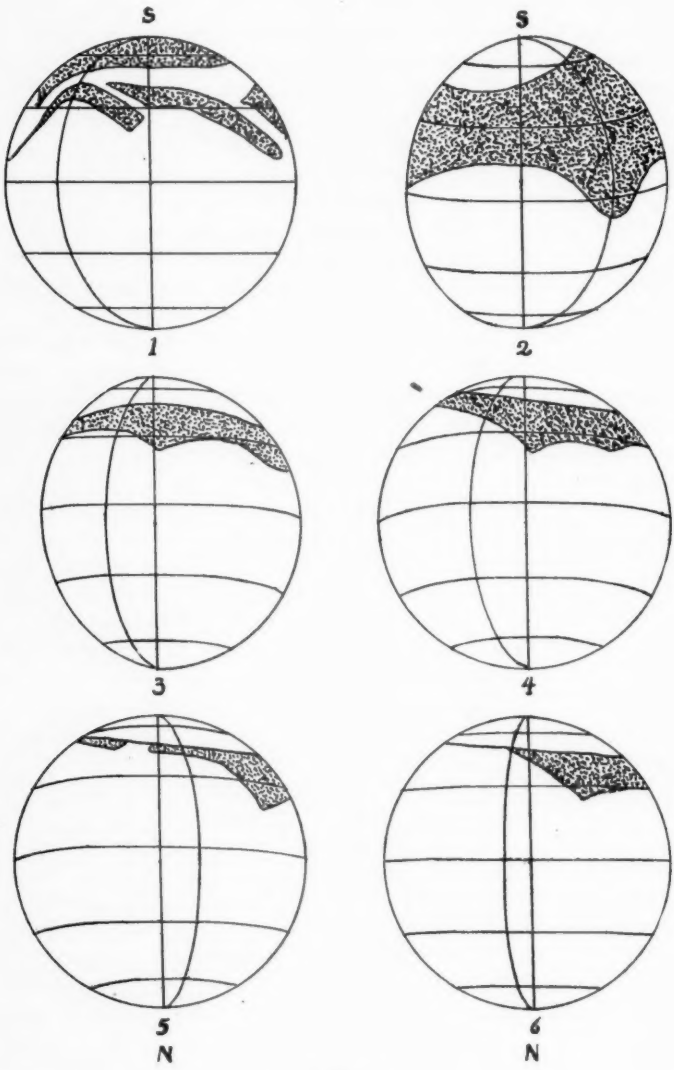



FIGURE 2.
SHOWING GRADUAL CHANGE IN LATITUDE AND LONGITUDE OF CERTAIN MARKINGS UPON MARS.

be hoped that this necessarily somewhat inadequate investigation will lead others who may have access to the original observations, to study them with the idea of throwing more light on this interesting question of a regular semi-annual flood, transmitted across the planet's surface from its melting snow areas.

Another matter brought up in our last Report has been investigated at more length since its original publication. This pertains to the gradual change in latitude of the northern boundary of the southern *maria* with the advance of the season. In the six drawings constituting Figure 2, the meridian of 140° is shown in each case as the arc of an ellipse, and the central meridian as a straight line. The equator and the parallels of 30° and 60° north and south latitude are also represented. The first drawing is taken from Schiaparelli's map in two hemispheres published in connection with our first Monthly Report. The other five are from drawings made at this station on the nights of August 6, October 12, December 19, December 25, and February 1.

The intersection of the boundary of the *maria* with the meridian of 140° on Schiaparelli's chart lies in latitude −35°. On the other figures it is successively +9°, −33°, −40°, −42° and −48°. In Lau's chart, *A.N.* 4706, it is placed in latitude −40°. On March 13 the planet was examined with the central meridian at 118° and the seeing 8, but no trace of any southern *maria* could be seen. It would seem that at that time the intersection must have advanced at least as far south as to latitude −60°. Clearly any future maps of Mars should be accompanied with the Martian date of the determination of each primary station.

It would appear that in the autumn the vegetation begins to die or turn yellow near the equator, and as winter approaches it retreats nearer and nearer to the pole,—the exact reverse of what occurs upon our earth. In Bulletin No. 12 of the Lowell Observatory it is shown that for the canals in the spring time vegetation advances from the pole to the equator, also the reverse of what happens upon the Earth. The high latitudes of Mars would therefore seem to support vegetation for a longer time than those near the equator, which also seems strange to us. On the other hand the northern polar marshes with the advance of spring retreat towards the pole, following the snow cap. The dark band surrounding the northern snow cap appears at about the end of February (Martian date), advances rapidly towards the equator for a terrestrial month, retreats as rapidly, and then in the form of a narrow dark line, save where interrupted by the marshes, retreats with the snow line.

But another curious feature is brought out by the drawings that we have not previously mentioned. Schiaparelli places Sinus Titanum

in longitude 170°, or 30° following the meridian we have represented in our drawings. In this Lau agrees with him. In the first drawing made at this station it is drawn in longitude 143°, and naturally the face of the planet was unrecognizable at the time. In the next drawing its longitude is 162°, the next 164°, then 170° and 175°. If Titanum shifts along through 30° of longitude, or even half as much, we can readily admit a deviation of 7° between Schiaparelli and Lau for the distance between Sabaeus and Margaritifer, as shown in our Report No. 3.

We must now discuss very briefly a few of the observations made here during the past few weeks. The northern snow cap has not diminished notably in size during that time. The dark line bounding it on the south has become extremely narrow. The southern cloud cap has fluctuated in size conspicuously, but has only occasionally been entirely absent. Little sunlight reaches the polar regions apparently during the few months preceding their long winter. No evidence of snow was seen near the south pole. But little cloud was visible elsewhere. The southern *maria* are still green, but are retreating southerly.

Although traces of blue are still to be seen in some of the four great polar marshes, yet they are now so remote, that no satisfactory evidence of polarization has been detected in the light reflected from their surfaces. This polarization has only been seen in the past for a few days at a time, and it probably requires a fairly large liquid surface for its detection. The theory of the phenomenon is that light coming from the Martian sky or clouds is reflected from the surface of the water and polarized. One ray coming through a double-image prism therefore shows the bottom of the Martian pool, while the other shows the sky reflected in its surface. One image therefore appears brighter than the other. In the case of a bucket of water the difference between two rays leaving its surface at an angle of 70° is readily recognized, and at lower angles the difference is very striking. The sensitiveness is greatly increased by combining a plate of quartz with the double image prism in the usual manner.

Nilosyrtis nearly disappeared February 24, but since it was again visible at the next presentation, at the end of March, it seems likely that the effect was produced at least in part by Martian clouds. A new canal, possibly Phison was detected, originating from near the junction of Thoth and Nilosyrtis, but it did not reach the equator, and ended in the desert, unless indeed it bent around following the course of Typhon. But this is uncertain. The northern twin bays were invisible March 11. Central meridian 151°. Seeing 6. They were not seen at all at this presentation. Lunae lacus was observed for the first time March 15, and the two canals Hydraotes and Nilokeras. The last two were indistinct and some 600 miles in breadth.

The following lakes and canals were recorded:—

Feb. 16. **6** Nilosyrtis.

Feb. 18. **5** Nilosyrtis, Thoth, Phison.

Feb. 24. **4**, **5** Nilosyrtis, Nepenthes, Thoth, Cerberus.

Feb. 25. **4** Thoth, Cerberus, Hephaestus, Cyclops, Eunostos Hyblaeus, Styx, Aesacus.

Mar. 15. **2** Lunae lacus, Nilokeras, Hydraotes.

TABLE OF DATA.

| No. | 1914 | ⊙ | M.D. | Long. | Lat. | Sun | Diam. | Seeing |
|---|---|---|---|---|---|---|---|---|
| | | ° | | ° | | | ″ | |
| 55 | Feb. 15 | 35.9 | Apr. 25 | 318 | +1 | +14 | 11.3 | 6,4 |
| 56 | 16 | 36.4 | " | 319 | " | " | | 10 |
| 57 | 18 | 37.3 | 26 | 295 | " | " | 11.0 | 10 |
| 58 | 24 | 40.0 | 29 | 235 | +2 | +15 | 10.3 | 6 |
| 59 | " | " | " | 281 | " | " | " | 8 |
| 60 | 25 | 40.4 | " | 224 | " | " | " | 6 |
| 61 | Mar. 13 | 47.4 | May 7 | 118 | +4 | +17 | 8.8 | 8 |
| 62 | 15 | 48.3 | 8 | 75 | " | +18 | 8.7 | 6 |

## THE HUNTER.

Afar on Night's stupendous glitt'ring plains
Gleams great Orion, mighty in the chase.
With mace aloft he toward his quarry strains
And flaunts his lion's pelt in Taurus' face.

On one foot poised, with one on Rigel laid,
The eager hunter presses his advance.
His jeweled belt and shining falchion's blade
His hundred other stellar gems enhance.

Bright Bellatrix he makes his shoulder tache,
And opposite wears ruddy Betelgeuse;
O'er all his stalwart figure jewels flash,
Each royal in the splendor of its hues.

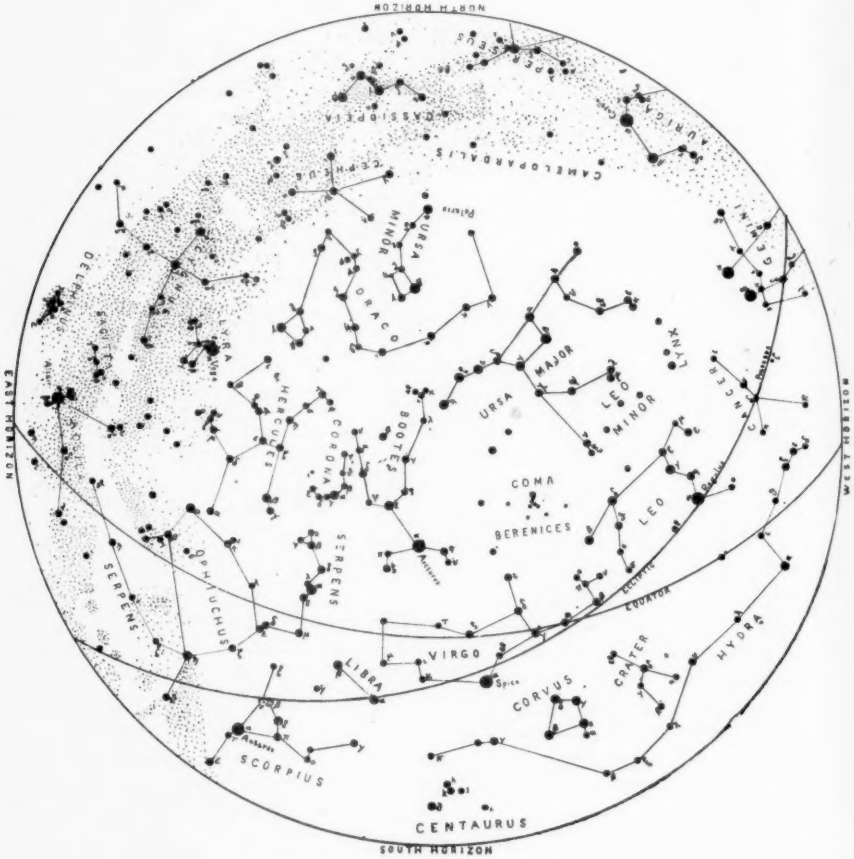
But lo! he hastes adown the distant west
To seek his prey in fields beyond our ken;
Yet all intent on his persistent quest,
When summer dies he'll mount our skies again.

ARIES.

Chicago Tribune, April 20, 1914.

## PLANET NOTES FOR JUNE, 1914.

The sun will be moving northward during the first part of the month and will reach its greatest northern declination on Monday, June 22. It will then immediately begin to move southward. Its path eastward will take it from Taurus into Gemini and by the end of the month it will be not very far from Castor and Pollux. By the end of the month the earth will be approaching its position of greatest distance from the sun.




THE CONSTELLATIONS AT 9:00 P. M. JUNE 1.

The phases of the moon for this month are as follows:

| | | | | |
|---|---|---|---|---|
| First Quarter | June | 1 | at 8 A.M. | C. S. T. |
| Full Moon | | 7 | " 11 P.M. | " |
| Last Quarter | | 15 | " 8 A.M. | " |
| New Moon | | 23 | " 10 A.M. | " |
| First Quarter | | 30 | " 1 A.M. | " |

*Mercury* will reach a point of greatest elongation east on June 18. At this time it will be an hour and a half east of the sun and will consequently be visible in the west after sunset. It will be at about the same declination as the sun. It will be a short distance almost directly south of Pollux.

*Venus* will continue to move eastward more rapidly than the sun. At the beginning of the month it will be farther north than the sun but will be moving southward rather rapidly. It will be a very conspicuous object in the evening sky during the month. More than eight tenths of the illuminated surface will be turned toward the earth, but it will be very distant from the earth and therefore not at its brightest. It will however be very much brighter than the brightest star in the sky and will be easily recognized on that account.

*Mars* will still be visible throughout the month. It will be several degrees farther south than the sun. It will be in the western sky at sunset. Mars will be receding from the earth and will be at nearly twice the earth's distance from the sun. Because of its distance it will be fainter than the well known star Aldebaran.

*Jupiter* will be coming into good position again. It will rise before midnight. It will be quite far south, however, for northern observers.

*Saturn* will be in conjunction with the sun on June 12. By the end of the month it will be emerging from the sun's rays again, and may be seen on the eastern horizon an hour before sunrise.

*Uranus* will not be very far from a position of opposition to the sun. It will therefore be above the horizon practically all night during this month.

*Neptune* will be rather low in the west at sunset and will be getting nearer to the sun each day. It will not be well situated for observation.

## Phenomena of Jupiter's Satellites.

[Visible at Washington.]

CENTRAL STANDARD TIME

| 1914 | h | m | | 1914 | h | m | |
|---|---|---|---|---|---|---|---|
| June 1 | 12 | 16 | I Ec. Dis. | June 17 | 10 | 33 | I Ec. Dis. |
| 2 | 11 | 48 | I Sh. Eg. | | 13 | 59 | I Oc. Re. |
| | 12 | 56 | II Tr. In. | 18 | 10 | 5 | II Ec. Dis. |
| | 13 | 5 | I Tr. Eg. | | 11 | 10 | I Tr. Eg. |
| | 13 | 16 | II Sh. Eg. | 20 | 10 | 2 | II Tr. Eg. |
| 4 | 10 | 20 | II Oc. Re. | 21 | 14 | 20 | IV Sh. Eg. |
| | 12 | 20 | III Oc. Dis. | 22 | 13 | 3 | III Tr. Eg. |
| 8 | 14 | 10 | I Ec. Dis. | 23 | 15 | 8 | I Sh. In. |
| 9 | 11 | 21 | I Sh. In. | 24 | 12 | 27 | I Ec. Dis. |
| 9 | 12 | 34 | I Tr. In. | 25 | 10 | 37 | I Tr. In. |
| | 12 | 56 | II Sh. In. | | 11 | 57 | I Sh. Eg. |
| | 13 | 41 | I Sh. Eg. | | 12 | 39 | II Ec. Dis. |
| | 14 | 54 | I Tr. Eg. | | 12 | 58 | I Tr. Eg. |
| 11 | 11 | 17 | III Ec. Dis. | 26 | 10 | 14 | I Oc. Re. |
| | 12 | 46 | II Oc. Re. | 27 | 9 | 29 | II Tr. In. |
| | 14 | 50 | III Ec. Re. | | 10 | 25 | II Sh. Eg. |
| 13 | 10 | 50 | IV Oc. Dis. | | 12 | 26 | II Tr. Eg. |
| 16 | 13 | 14 | I Sh. In. | 29 | 12 | 45 | III Sh. Eg. |
| | 14 | 23 | I Tr. In. | | 12 | 52 | III Tr. In. |

Note:—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

**Occultations Visible at Washington.**

| Date 1914 | Star's Name | Magnitude | IMMERSION. Washington M.T. h m | IMMERSION. Angle f'm N. ° | EMERSION. Washington M.T. h m | EMERSION. Angle f'm N. ° | Duration h m |
|---|---|---|---|---|---|---|---|
| June 3 | $\psi$ Virginis | 5.0 | 6 20 | 130 | 7 33 | 309 | 1 13 |
| 6 | *b* Scorpii | 4.7 | 7 15 | 91 | 8 16 | 318 | 1 1 |
| 6 | 4 Scorpii | 5.7 | 9 36 | 104 | 10 54 | 298 | 1 17 |
| 8 | C.D.—28°14268 | 6.4 | 12 20 | 69 | 13 40 | 284 | 1 19 |
| 8 | 62 B. Sagittarii | 6.0 | 15 27 | 49 | 16 29 | 286 | 1 2 |
| 11 | $\eta$ Capricorni | 4.8 | 10 24 | 27 | 11 8 | 302 | 0 44 |
| 30 | $\chi$ Virginis | 4.8 | 6 13 | 119 | 7 28 | 319 | 1 15 |

## VARIABLE STARS.

**New Variable Stars.**—A new variable, 6.1914 Canum Venaticorum, is announced in *A. N.* 4717, having been discovered by Mme. L. Ceraski. A discussion of 23 plates of that region taken between 1908 and 1913 indicates that the star varies from $9^m.5$ to $11^m.0$. Sometimes the light changes by a magnitude in a day. It is therefore a star of short period or very irregular.

A new variable, 7.1914 Cassiopeiae, in position for 1900 $\alpha = 0^h\ 30^m.5$ $\delta = +57°\ 22'.9$, is announced in *A.N.* 4718 by C. R. D'Esterre. It is apparently of long period since computed times of maxima based upon a period of 291 days accord very well with observations. The last maximum occurred about January 22, 1914. It is very faint at minimum, of about 18.2 magnitude, and rises to about 10.7 magnitude at maximum.

In *A.N.* 4719 four new variables are announced as follows:

(1) 8.1914 Pegasi, whose position for 1900 is $\alpha = 22^h\ 51^m\ 40^s$, $\delta = +32°\ 41'.7$, is of the Algol type. This star is normally of about $10^m$, but at intervals of a little more than five days it drops to about 10.5 magnitude and returns to normal again in about 2½ hours. The elements are given as follows:

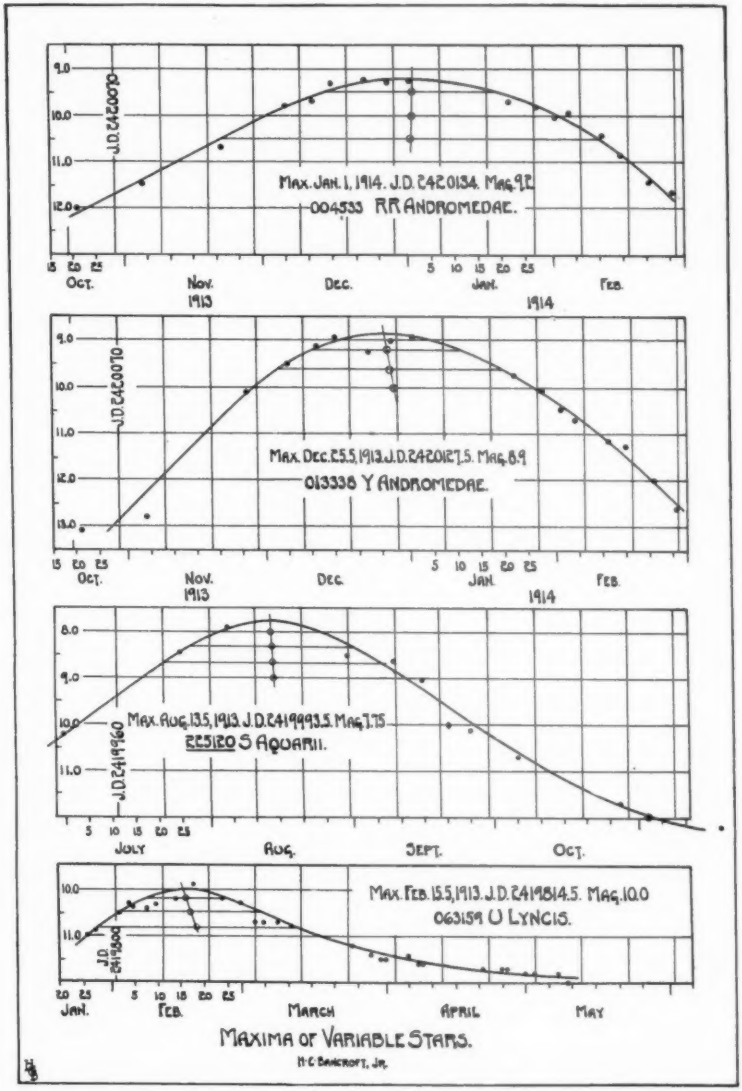
Min. = J.D. 2415729.460 + $5^d.26792$ E.

(2) 9.1914 Böotis, in position for 1900 $\alpha = 13^h\ 55^m\ 6^s.1$ $\delta = +28°\ 16'.4$, was found by Mme. L. Ceraski. This star varies from 10.4 to 11.7 magnitude, but the type cannot be determined now with certainty.

(3) 10.1914 Canum Venaticorum, in position for 1900 $\alpha = 13^h\ 5^m\ 58^s.9$ $\delta = +36°\ 27'.9$, was found by Mme. L. Ceraski on February 23. This star is known as BD + 36°.2344 of magnitude 7.5. On 25 plates taken during the interval from 1896 to 1913 this star is apparently constant and of the magnitude given, but on three other plates it is found to be respectively 1½, 1 and 1 magnitude fainter. It seems therefore to be of the Algol type.

(4) 11.1914 Böotis, in position for 1900 $\alpha = 13^h\ 58^m\ 42^s$ $\delta = +29°\ 12'$, also was discovered by Mme. L. Ceraski. This star was found on 25 plates and varies approximately from $10^m$ to $12^m$. Its type is uncertain, and the period is probably long.

In *A. N.* 4720 the new variable 12.1914 Cassiopeiae is announced by C. R. D'Esterre. Its position in 1900 is given $\alpha = 0^h\ 8^m\ 3^s$ $\delta = +62°\ 53'.7$. "The observations establish a range of variation of $12^m.0$ to $13^m.8$, but there is no clear evidence of a regular period."


9.0
10.0
11.0
12.0
J.D. 2420070
Max. Jan. 1, 1914. J.D. 2420134. Mag. 9.2
004533 RR Andromedae.
15 20 25
Oct.
Nov.
1913
Dec.
5 10 15 20 25
Jan.
1914
Feb.
9.0
10.0
11.0
12.0
13.0
J.D. 2420070
Max. Dec. 25.5, 1913. J.D. 2420167.5. Mag. 8.9
013338 Y Andromedae.
15 20 25
Oct.
Nov.
1913
Dec.
5 10 15 20 25
Jan.
1914
Feb.
8.0
9.0
10.0
11.0
J.D. 2419960
Max. Aug. 13.5, 1913. J.D. 2419993.5. Mag. 7.75
225120 S Aquarii.
5 10 15 20 25
July
Aug.
Sept.
Oct.
10.0
11.0
J.D. 2419800
Max. Feb. 15.5, 1913. J.D. 2419814.5. Mag. 10.0
063159 U Lyncis.
20 25
Jan.
5 10 15 20 25
Feb.
March
April
May
Maxima of Variable Stars.
H. C. Bancroft, Jr.

## Approximate Magnitudes of Variable Stars of Long Period on Apr. 1, 1914.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

| Name. | R. A. 1900. h m | Decl. 1900. ° ′ | Magn. | Name. | R.A. 1900 h m | Decl. 1900 ° ′ | Magn. |
|---|---|---|---|---|---|---|---|
| X Androm. | 0 10.8 | +46 27 | 10.8 *i* | Nova. Gem. | 6 45.5 | +32 17 | 11.4 |
| T Androm. | 17.2 | +26 26 | 9.8 *i* | Y Monoc. | 51.3 | +11 22 | 12.2*d* |
| T Cassiop. | 17.8 | +55 14 | 10.0*d* | X Monoc. | 52.4 | — 8 56 | 7.4 |
| Y Cephei | 31.3 | +79 48 | 11.4*d* | R Lyncis | 53.0 | +55 28 | 7.4 |
| U Cassiop. | 40.8 | +47 43 | 8.8 *i* | V Can. Min. | 7 1.5 | + 9 2 | 14.0 |
| RW Androm. | 41.9 | + 32 8 | 9.6 | R Gemin. | 1.3 | +22 52 | 12.6 |
| RV Cassiop. | 47.1 | +46 53 | 13.0*d* | R Can. Min. | 3.2 | +10 11 | 10.6 |
| W Cassiop. | 49.0 | +58 1 | 9.0 | RR Monoc. | 12.4 | + 1 17 | 11.7 |
| U Androm. | 1 9.8 | +40 11 | 12.2*d* | V Gemin. | 17.6 | +13 17 | 9.1 |
| – Androm. | 10.4 | +41 12 | <13.0 | S Can. Min. | 27.3 | + 8 32 | 8.0*d* |
| S Cassiop. | 12.3 | +72 5 | <13.0 | U Can.Min. | 35.9 | + 8 37 | 12.6 |
| RZ Persei | 23.6 | +50 20 | 11.6*i* | S Gemin. | 37.0 | +23 41 | 12.2*d* |
| RU Androm. | 32.8 | +38 10 | 13.0 | T Gemin. | 43.3 | +23 59 | 8.5 *i* |
| Y Androm. | 33.7 | +38 50 | 13.6 | R Cancri | 8 11.0 | +12 2 | 10.0 |
| X Cassiop. | 49.8 | +58 46 | 10.6 | V Cancri | 16.0 | +17 36 | 11.8*d* |
| U Persei | 53.0 | + 54 20 | 7.8 | T Lyncis | 16.4 | +33 51 | 12.2 |
| R Arietis | 2 10.4 | +24 35 | 8.5 | RT Hydrae | 24.7 | — 5 59 | 7.8 |
| W Androm. | 11.2 | +43 50 | 10.0*d* | U Cancri | 30.0 | + 19 14 | 9.8 |
| Z Cephei | 12.8 | +81 13 | <14.0 | T Hydrae | 50.8 | — 8 46 | 9.4 |
| *o* Ceti | 14.3 | — 3 26 | 3.4 | T Cancri | 51.0 | +20 14 | 8.4 |
| S Persei | 15.7 | +58 8 | 11.0 | W Cancri | 9 4.0 | +25 39 | 11.6 |
| R Ceti | 20.9 | — 0 38 | 8.6 | Y Draconis | 31.1 | +78 18 | 14.3 |
| RR Persei | 21.7 | +50 49 | 14.0 | R Leo. Min. | 39.6 | +34 58 | 9.5*d* |
| RR Cephei | 29.4 | +80 42 | 12.3*d* | R Leonis | 42.2 | +11 54 | 7.2*d* |
| R Trianguli | 31.0 | +33 50 | 9.8 | Y Hydrae | 46.4 | —22 33 | 6.2 |
| W Persei | 43.2 | +56 34 | 9.2 | R Urs. Maj. | 10 37.6 | +69 18 | 11.0 *i* |
| U Arietis | 3 5.5 | +14 25 | 9.0*d* | V Hydrae | 46.8 | —20 43 | 6.4 |
| X Ceti | 14.3 | — 1 26 | 12.0*d* | W Leonis | 48.4 | +14 15 | <13.0 |
| Y Persei | 20.9 | +43 50 | 8.5 | R Crateris | 55.6 | —17 47 | 8.0 |
| R Persei | 23.7 | +35 20 | 10.9 | R Com. Ber. | 11 59.1 | +19 20 | <12.0 |
| R Tauri | 4 22.8 | + 9 56 | 10.0 | SU Virginis | 12 0.0 | +12 56 | 12.5 |
| W Tauri | 22.2 | +15 49 | 11.3*d* | T Virginis | 9.5 | — 5 29 | 10.0 *i* |
| S Tauri | 23.7 | + 9 44 | <12.0 | R Corvi | 14.4 | —18 42 | 12.4 |
| T Camelop. | 30.4 | +65 57 | 9.2 | SS Virginis | 20.1 | + 1 19 | 7.6*d* |
| R Tauri | 32.8 | + 8 9 | 10.0*d* | T Can. Ven. | 25.2 | +32 3 | 10.4*d* |
| X Camelop. | 32.6 | +74 56 | 8.4 | T Urs. Maj. | 31.8 | +60 2 | 8.0 *i* |
| V Tauri | 46.2 | +17 22 | 12.0*d* | R Virginis | 33.4 | + 7 32 | 10.8*d* |
| R Orionis | 53.6 | + 7 59 | 9.5 | RS Urs. Maj. | 34.4 | +59 2 | 14.0 |
| R Leporis | 55.0 | —14 57 | 7.2 | S Urs. Maj. | 39.6 | +61 38 | 8.2*d* |
| V Orionis | 5 0.8 | + 3 58 | <12.0 | U Virginis | 46.0 | + 6 6 | 11.0*d* |
| T Leporis | 0.6 | —22 2 | 10.6 | R Hydrae | 13 24.2 | —22 46 | 4.3 |
| R Aurigae | 9.2 | +53 28 | 8.7*d* | S Virginis | 27.8 | — 6 41 | 9.4*d* |
| W Aurigae | 20.1 | +36 49 | 11.8*d* | T Urs. Min. | 32.6 | +73 56 | 12.6*d* |
| S Orionis | 24.1 | — 4 46 | 12.3 | R Can. Ven. | 44.6 | +40 2 | 7.0 *i* |
| SU Tauri | 43.2 | +19 2 | <14.0 | U Urs. Min. | 14 15.1 | +67 15 | 8.5 |
| RU Tauri | 46.9 | +15 57 | 13.3 | S Bootis | 19.5 | +54 16 | 8.6 |
| U Orionis | 49.9 | +20 10 | 9.7 *i* | RS Virginis | 22.3 | + 5 8 | 13.4 *i* |
| V Camelop. | 49.4 | +74 30 | <14.0 | V Bootis | 25.7 | +39 18 | 9.1 *i* |
| Z Aurigae | 53.6 | +53 18 | 11.3 | R Camelop. | 25.1 | +84 17 | 8.3 |
| X Aurigae | 6 4.4 | +50 15 | 8.4 | R Bootis | 32.8 | +27 10 | 10.3*d* |
| V Aurigae | 16.5 | +47 45 | 10.4*d* | RU Librae | 15 27.7 | —14 59 | 12.4 *i* |
| V Monoc. | 17.7 | — 2 9 | 7.6*d* | S Urs. Min. | 33.4 | +78 58 | 11.6 |
| U Lyncis | 31.8 | +59 57 | 11.0 *i* | V Cor. Bor. | 46.0 | +39 52 | 8.4*d* |
| S Lyncis | 35.9 | +58 0 | 12.5 *i* | W Cor. Bor. | 16 11.8 | +38 3 | 11.6 |
| X Gemin. | 40.7 | +30 23 | 9.0 *i* | U Herculis | 21.4 | +19 7 | 7.0 |

## Approximate Magnitudes of Variable Stars of Long Period on Apr. 1, 1914.—Continued.

| Name. | R. A. 1900. h m | Decl. 1900. ° ′ | Magn. | Name. | R.A. 1900. h m | Dec. 1900. ° ′ | Magn. |
|---|---|---|---|---|---|---|---|
| R Urs. Min. | 16 31.3 | +72 28 | 10.8 | R Cygni | 19 34.1 | +49 58 | 6.6 |
| R Draconis | 32.4 | +66 58 | 7.8 | RT Cygni | 40.8 | +48 32 | 6.6 |
| T Draconis | 17 54.8 | +58 14 | 10.9 | TU Cygni | 43.3 | +48 49 | 12.3*d* |
| V Draconis | 56.3 | +54 53 | 11.8 *i* | χ Cygni | 46.7 | +32 40 | 11.0*d* |
| T Herculis | 18 5.3 | +31 0 | 7.8 | V Sagittae | 20 15.8 | +20 47 | 12.8 |
| SV Draconis | 31.2 | +49 18 | 12.9 | ST Cygni | 29.9 | +54 38 | 13.3 |
| RY Lyrae | 41.2 | +34 34 | 9.3 | TW Cygni | 21 1.8 | +29 0 | 13.5 |
| Z Lyrae | 56.0 | +34 49 | 13.7 | X Cephei | 3.6 | +82 40 | <14.0 |
| V Lyrae | 19 5.2 | +29 30 | 9.4 | R Equulei | 8.4 | +12 23 | <12.0 |
| S Lyrae | 9.1 | +25 50 | 13.8 | T Cephei | 8.2 | +68 5 | 10.2 |
| U Draconis | 9.9 | +67 7 | 11.5 *i* | S Cephei | 36.5 | +78 10 | 11.7 |
| TZ Cygni | 13.4 | +50 0 | 11.3 | Z Cassiop. | 23 39.7 | +56 2 | 13.1*d* |
| U Lyrae | 16.6 | +37 42 | 8.7 | R Cassiop. | 53.3 | +50 50 | 12.5*d* |

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign < that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—H. C. Bancroft, Jr., T. C. H. Bouton, N. Bruseth, A. B. Burbeck, E. Gray, S. C.Hunter, M. W. Jacobs, Jr., J. B. Lacchini, F. C. Leonard, C. Y. McAteer, W. T. Olcott, E. Padova, C. Richter, D. Todd, H. W. Vrooman, I. E. Woods and A. S. Young.

## Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes and May E. Abbott at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5$^h$; Central standard time 6$^h$; etc.

| Star | R. A. 1900 h m | Decl. 1900 ° ′ | Magnitude | Approx. Period d h | Greenwich mean times of maxima in 1914 June d h; d h; d h; d h; d h |
|---|---|---|---|---|---|
| SX Cassiop. | 0 05.5 | +54 20 | 8.6— 9.4 | 36 13.7 | 5 20 |
| SY Cassiop. | 0 09.8 | +57 52 | 9.3— 9.9 | 4 1.7 | 4 11; 12 14; 20 18; 28 21 |
| RR Ceti | 1 27.0 | + 0 50 | 8.3— 9.0 | 0 13.3 | 3 14; 11 8; 19 2; 26 19 |
| RW Cassiop. | 1 30.7 | +57 15 | 8.9—11.0 | 14 19.2 | 4 22; 19 17 |
| V Arietis | 2 09.6 | +11 46 | 8.3— 9.0 | 0 23.8 | 5 19; 13 18; 21 16; 29 15 |
| SU Cassiop. | 2 43.0 | +68 28 | 6.5— 7.0 | 1 22.8 | 8 16; 16 11; 24 6 |
| TU Persei | 3 01.8 | +52 49 | 11.4—12.2 | 0 14.6 | 6 8; 13 15; 20 22; 28 4 |
| RW Camelop. | 3 46.2 | +58 21 | 8.2— 9.4 | 16 00.0 | 5 0; 21 0 |
| SX Persei | 4 10.2 | +41 27 | 10.4—11.2 | 4 07.0 | 6 21; 15 11; 24 1 |
| SV Persei | 42.8 | +42 07 | 8.8— 9.6 | 11 03.1 | 6 3; 17 6; 28 9 |
| RX Aurigae | 4 54.5 | +39 49 | 7.2— 8.1 | 11 15.0 | 8 0; 19 15; |
| SX Aurigae | 5 04.6 | +42 02 | 8.0— 8.7 | 1 12.8 | 4 16; 12 8; 20 0; 27 15 |
| SY Aurigae | 05.5 | +42 41 | 8.4— 9.5 | 10 03.3 | 2 13; 12 17; 22 20 |
| Y Aurigae | 21.5 | +42 21 | 8.6— 9.6 | 3 20.6 | 6 17; 14 10; 22 3; 29 20 |
| RZ Gemin. | 5 56.6 | +22 12 | 9.1—10.0 | 5 12.7 | 2 16; 8 4; 19 6; 30 7 |
| RS Orionis | 6 16.5 | +14 44 | 8.2— 8.9 | 7 13.6 | 3 8; 10 22; 18 11; 26 1 |
| T Monoc. | 19.8 | + 7 08 | 5.7— 6.8 | 27 00.3 | 19 11 |
| RZ Camelop. | 23.7 | +67 06 | 11.0—13.0 | 0 11.5 | 5 4; 12 9; 19 14; 26 19 |
| W Gemin. | 29.2 | +15 24 | 6.7— 7.5 | 7 22.0 | 3 20; 11 18; 19 16; 27 14 |
| ζ Gemin. | 6 58.2 | +20 43 | 3.7— 4.3 | 10 03.7 | 2 18; 12 21; 23 1 |
| RU Camelop. | 7 10.9 | +69 51 | 8.5— 9.8 | 22 06.5 | 8 10; 30 16 |
| RR Gemin. | 7 15.2 | +31 04 | 10.0—11.5 | 0 09.5 | 3 14; 11 13; 19 12; 27 10 |

**Maxima of Variable Stars of Short Period.**—Continued.

| Star | R.A. 1900 | Decl. 1900 | Magnitude | Approx. Period | Greenwich mean times of maxima in 1914. June | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | | d h | d h | d h | d h | d h | d h | d h | d h | d h |
| V Carinae | 8 26.7 | −59 47 | 7.4— 8.1 | 6 16.7 | 5 3; | 11 20; | 18 12; | 25 5 | | | | |
| T Velorum | 8 34.4 | −47 01 | 7.6— 8.5 | 4 15.3 | 8 22; | 18 5; | 27 11 | | | | | |
| V Velorum | 9 19.2 | −55 32 | 7.5— 8.2 | 4 08.9 | 8 23; | 17 16; | 26 10 | | | | | |
| Z Leonis | 9 46.4 | +27 22 | 7.9— 9.6 | 59 0.0 | | 19 0 | | | | | | |
| RR Leonis | 10 02.1 | +24 29 | 9.1 −10.1 | 0 10.9 | 3 5; | 10 0; | 23 13; | 40 8 | | | | |
| SU Draconis | 11 32.2 | +67 53 | 8.9— 9.6 | 0 15.8 | 7 12; | 14 2; | 20 17; | 27 7 | | | | |
| S Muscae | 12 07.4 | −69 36 | 6.4— 7.3 | 9 15.8 | 8 6; | 17 22; | 27 13 | | | | | |
| SW Draconis | 12.8 | +70 04 | 8.8— 9.6 | 0 13.7 | 3 19; | 11 19; | 19 18; | 27 18 | | | | |
| T Crucis | 15.9 | −61 44 | 6.8— 7.6 | 6 17.6 | 2 4; | 8 22; | 22 9; | 29 2 | | | | |
| R Crucis | 18.1 | −61 04 | 6.8— 7.9 | 5 19.8 | 3 6; | 9 1; | 20 17; | 26 13 | | | | |
| S Crucis | 12 48.4 | −57 53 | 6.5— 7.6 | 4 16.6 | 4 23; | 9 16; | 19 1; | 28 10 | | | | |
| W Virginis | 13 20.9 | − 2 52 | 8.7—10.4 | 17 06.5 | 6 6; | 23 13 | | | | | | |
| SS Hydrae | 25.0 | −23 08 | 7.4— 8.1 | 8 4.8 | 5 19; | 14 0; | 22 5; | 30 10 | | | | |
| RV Urs. Maj. | 13 29.4 | +54 31 | 9.2— 9.9 | 0 11.2 | 6 16; | 13 16; | 20 17; | 27 17 | | | | |
| ST Virginis | 14 22.5 | − 0 27 | 10.3—11.4 | 0 09.9 | 2 3; | 10 8; | 18 13; | 26 18 | | | | |
| V Centauri | 25.4 | −56 27 | 6.4— 7.8 | 5 11.9 | 4 17; | 10 5; | 21 5; | 26 17 | | | | |
| RS Bootis | 29.3 | +32 11 | 8.9—10.0 | 0 09.1 | 4 10; | 11 23; | 19 12; | 27 1 | | | | |
| RU Bootis | 14 41.5 | +23 44 | 12.8 −14.3 | 0 11.9 | 5 18; | 13 4; | 20 14; | 28 0 | | | | |
| R Triang. Austr. | 15 10.8 | −66 08 | 6.7— 7.4 | 3 09.3 | 4 16; | 11 11; | 18 6; | 25 0 | | | | |
| S Triang. Austr. | 15 52.2 | −63 29 | 6.4— 7.4 | 6 07.8 | 6 13; | 12 21; | 19 5; | 25 13 | | | | |
| S Normae | 16 10.6 | −57 39 | 6.6— 7.6 | 9 18.1 | 2 1; | 11 19; | 21 13 | | | | | |
| RW Draconis | 33.7 | +58 03 | 9.6—10.8 | 0 10.6 | 2 9; | 11 6; | 20 2; | 28 23 | | | | |
| RV Scorpii | 16 51.8 | −33 27 | 6.7— 7.4 | 6 01.5 | 4 1; | 10 2; | 22 5; | 28 7 | | | | |
| X Sagittarii | 17 41.3 | −27 48 | 4.4— 5.0 | 7 00.3 | 1 19; | 8 20; | 22 20; | 29 21 | | | | |
| Y Ophiuchi | 47.3 | − 6 07 | 6.1— 6.5 | 17 02.9 | | 18 2 | | | | | | |
| W Sagittarii | 17 58.6 | −29 35 | 4.3— 5.1 | 7 14.3 | 2 16; | 10 6; | 17 20; | 25 10 | | | | |
| Y Sagittarii | 18 15.5 | −18 54 | 5.4— 6.2 | 5 18.6 | 6 2; | 11 21; | 23 10; | 29 5 | | | | |
| U Sagittarii | 26.0 | −19 12 | 6.5— 7.3 | 6 17.9 | 6 10; | 13 4; | 19 21; | 26 15 | | | | |
| Y Scuti | 32.6 | − 8 27 | 8.7— 9.2 | 10 08.3 | 6 12; | 16 21; | 27 5 | | | | | |
| Y Lyrae | 34.2 | +43 52 | 11.3—12.3 | 0 12.1 | 6 12; | 12 13; | 24 15; | 30 15 | | | | |
| RZ Lyrae | 39.9 | +32 42 | 9.9—11.2 | 0 12.3 | 6 20; | 12 23; | 19 2; | 25 5 | | | | |
| RT Scuti | 44.1 | −10 30 | 9.1— 9.7 | 0 11.9 | 2 14; | 8 13; | 20 10; | 26 9 | | | | |
| κ Pavonis | 18 46.6 | −67 22 | 3.8— 5.2 | 9 02.2 | 9 10; | 18 12; | 27 14 | | | | | |
| U Aquilae | 19 24.0 | − 7 15 | 6.2— 6.9 | 7 00.6 | 7 18; | 14 18; | 21 19; | 28 19 | | | | |
| XZ Cygni | 30.4 | +56 10 | 8.6— 9.3 | 0 11.2 | 3 10; | 10 10; | 17 10; | 24 10 | | | | |
| U Vulpec. | 32.2 | +20 07 | 6.5— 7.6 | 7 23.5 | 5 1; | 13 0; | 21 0; | 28 23 | | | | |
| SU Cygni | 40.8 | +29 01 | 6.2— 7.0 | 3 20.3 | 2 14; | 10 7; | 17 23; | 25 16 | | | | |
| η Aquilae | 47.4 | + 0 45 | 3.7— 4.5 | 7 04.2 | 4 11; | 11 15; | 18 19; | 25 23 | | | | |
| S Sagittae | 51.5 | +16 22 | 5.6— 6.4 | 8 09.2 | 8 9; | 16 18; | 25 3 | | | | | |
| X Vulpec. | 19 53.3 | +26 17 | 9.5—10.5 | 6 07.7 | 4 16; | 11 0; | 23 15; | 29 23 | | | | |
| X Cygni | 20 39.5 | +35 14 | 6.0— 7.0 | 16 09.3 | | 16 12 | | | | | | |
| T Vulpec. | 47.2 | +27 52 | 5.5— 6.1 | 4 10.5 | 1 21; | 10 18; | 19 14; | 28 11 | | | | |
| WY Cygni | 52.3 | +30 03 | 9.6—10.4 | 0 13.5 | 3 9; | 10 2; | 23 13; | 30 7 | | | | |
| RV Capric. | 55.9 | −15 37 | 9.2—10.1 | 0 10.7 | 4 2; | 10 19; | 24 5; | 30 23 | | | | |
| TX Cygni | 20 56.4 | +42 12 | 8.5— 9.7 | 14 17.4 | | 13 9; | 28 2 | | | | | |
| VY Cygni | 21 00.4 | +39 34 | 8.8— 9.5 | 7 20.6 | 8 17; | 16 14; | 24 10 | | | | | |
| SW Aquarii | 10.2 | − 0 20 | 9.9—10.8 | 0 11.0 | 1 18; | 8 15; | 22 10; | 29 7 | | | | |
| VZ Cygni | 21 47.7 | +42 40 | 8.2— 9.2 | 4 20.7 | 2 10; | 7 7; | 17 0; | 26 18 | | | | |
| Y Lacertae | 22 05.2 | +50 33 | 9.1— 9.6 | 4 07.8 | 4 21; | 13 12; | 22 4; | 30 19 | | | | |
| δ Cephei | 25.5 | +57 54 | 3.7— 4.6 | 5 08.8 | 4 2; | 9 11; | 20 4; | 30 22 | | | | |
| Z Lacertae | 36.9 | +56 18 | 8.2— 9.0 | 10 21.1 | 8 10; | 19 7; | 30 4 | | | | | |
| RR Lacertae | 37.5 | +55 55 | 8.5— 9.2 | 6 10.1 | 4 20; | 11 6; | 24 2; | 30 12 | | | | |
| V Lacertae | 22 44.5 | +55 48 | 8.2— 8.9 | 4 23.6 | 5 4; | 10 4; | 20 3; | 30 2 | | | | |
| SW Cassiop. | 23 03.7 | +58 11 | 9.2— 9.7 | 5 10.6 | 5 20; | 11 7; | 22 4; | 27 14 | | | | |
| RS Cassiop. | 32.6 | +61 52 | 9.0—11.0 | 6 07.1 | 1 18; | 8 1; | 20 16; | 26 23 | | | | |
| RY Cassiop. | 47.2 | +58 11 | 9.3—11.8 | 12 03.4 | 9 3; | 21 6 | | | | | | |
| V Cephei | 23 51.7 | +82 38 | 6.0— 7.0 | 0 23.9 | 4 5; | 9 4; | 19 4; | 29 3 | | | | |

## Minima of Variable Stars of Short Period.

[Calculated by May E. Abbott, at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract $5^h$; Central Standard $6^h$; etc.

| Star | R. A. 1900 | Decl. 1900 | Magnitude | Approx. Period | Greenwich mean times of minima in 1914 June | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | | d h | d h | d h | d h | d h | d h | d h | d h | d h |
| SY Androm. | 0 08.0 | +43 09 | 9.5—13.0 | 34 21.8 | | | 25 19 | | | | | |
| RT Sculptor. | 31.5 | −26 13 | 9.6—10.5 | 0 12.3 | 5 15; | 13 7; | 20 23; | 28 15 | | | | |
| UU Androm. | 38.5 | +30 24 | 10.7—11.9 | 1 11.7 | 3 23; | 11 10; | 18 20; | 26 6 | | | | |
| U Cephei | 0 53.4 | +81 20 | 7.0— 9.0 | 2 11.8 | 3 10; | 10 21; | 18 9; | 25 20 | | | | |
| Z Persei | 2 33.7 | +41 46 | 9.4—12 | 3 01.4 | 4 18; | 10 21; | 23 2; | 29 5 | | | | |
| TW Cassiop. | 37.6 | +65 19 | 8.2— 9.0 | 1 10.3 | 6 17; | 13 20; | 21 0; | 28 3 | | | | |
| RY Persei | 39.0 | +47 43 | 8.0—10.3 | 6 20.7 | 5 12; | 12 9; | 19 6; | 26 3 | | | | |
| RZ Cassiop. | 39.9 | +69 13 | 6.9— 8.1 | 1 04.7 | 6 23; | 14 3; | 21 7; | 28 11 | | | | |
| TX Cassiop. | 44.4 | +62 22 | 9.4—10.1 | 2 22.2 | 6 17; | 15 12; | 24 6 | | | | | |
| ST Persei | 53.7 | +38 47 | 8.5—10.5 | 2 15.6 | 7 2; | 15 2; | 23 1; | 30 23 | | | | |
| RX Cassiop. | 2 58.8 | +67 11 | 8.6— 9.1 | 32 07.6 | 6 7 | | | | | | | |
| Algol | 3 01.7 | +40 34 | 2.3— 3.5 | 2 20.8 | 1 22; | 7 15; | 19 3; | 30 14 | | | | |
| RT Persei | 16.7 | +46 12 | 9.5—11.5 | 0 20.4 | 4 11; | 11 6; | 18 1; | 24 20 | | | | |
| λ Tauri | 55.1 | +12 12 | 3.3— 4.2 | 3 22.9 | 5 6; | 13 3; | 21 1; | 28 23 | | | | |
| RW Tauri | 3 57.8 | +27 51 | 7.1—<11 | 2 18.5 | 7 7; | 15 14; | 23 20 | | | | | |
| RV Persei | 4 04.2 | +33 59 | 9.5—11.0 | 1 23.4 | 3 7; | 11 4; | 19 2; | 26 23 | | | | |
| RW Persei | 13.3 | +42 04 | 8.8—11.0 | 15 04.8 | 11 7; | 24 11 | | | | | | |
| SZ Tauri | 31.4 | +18 20 | 7.2— 7.7 | 3 03.6 | 1 17; | 11 4; | 20 15; | 30 1 | | | | |
| RS Cephei | 4 48.6 | +80 06 | 9.5—12.0 | 12 10.1 | 11 4; | 23 14 | | | | | | |
| TT Aurigae | 5 02.8 | +39 27 | 7.8— 8.7 | 0 16.0 | 1 8; | 8 0; | 21 8; | 28 0 | | | | |
| RY Aurigae | 11.5 | +38 13 | 10.7—11.7 | 2 17.5 | 3 21; | 9 8; | 20 6; | 25 17 | | | | |
| RZ Aurigae | 42.9 | +31 40 | 10.6—13.3 | 3 00.3 | 2 8; | 8 8; | 20 9; | 26 10 | | | | |
| SV Tauri | 45.8 | +28 05 | 9.4—11.0 | 2 04.0 | 2 20; | 11 12; | 20 4; | 28 20 | | | | |
| Z Orionis | 50.2 | +13 40 | 9.7—10.7 | 5 04.9 | | 10 12; | 20 22 | | | | | |
| SV Gemin. | 54.6 | +24 28 | 9.8—<11 | 4 00.2 | 5 7; | 13 8; | 21 8; | 29 8 | | | | |
| RW Gemin. | 5 55.4 | +23 08 | 9.5—11.0 | 2 20.8 | 4 11; | 10 5; | 21 16; | 27 9 | | | | |
| U Columbae | 6 11.2 | −33 03 | 9.2—10.0 | 2 19.2 | 3 19; | 9 10; | 20 15; | 26 5 | | | | |
| SX Gemin. | 22.0 | +20 37 | 10.8—11.5 | 1 08.8 | 7 14; | 15 19; | 23 23 | | | | | |
| RW Monoc. | 29.3 | + 8 54 | 9.0—10.8 | 1 21.7 | 4 4; | 11 19; | 19 10; | 27 1 | | | | |
| RX Gemin. | 43.6 | +33 21 | 8.8— 9.6 | 12 05.0 | 5 14; | 17 19; | 30 0 | | | | | |
| RU Monoc. | 6 49.4 | − 7 28 | 9.8—10.5 | 0 21.5 | 5 13; | 12 17; | 19 21; | 27 2 | | | | |
| R Can. Maj. | 7 14.9 | −16 12 | 5.8— 6.4 | 1 03.3 | 8 15; | 17 17; | 26 20 | | | | | |
| RY Gemin. | 21.7 | +15 52 | 8.9—<10 | 9 07.2 | 9 23; | 19 6; | 28 13 | | | | | |
| Y Camelop. | 27.6 | +76 17 | 9.5—12 | 3 07.3 | 8 21; | 18 19; | 28 17 | | | | | |
| TX Gemin. | 30.3 | +17 8 | 10.0—11.9 | 2 19.2 | 1 5; | 9 15; | 18 0; | 26 10 | | | | |
| RR Puppis | 43.5 | −41 08 | 9.4—10.7 | 6 10.3 | 4 3; | 10 14; | 23 10; | 29 21 | | | | |
| V Puppis | 7 55.4 | −48 58 | 4.1— 4.8 | 1 10.9 | 2 10; | 9 16; | 16 23; | 24 6 | | | | |
| X Carinae | 8 29.1 | −58 53 | 7.9— 8.7 | 0 13.0 | 6 20; | 14 23; | 23 2 | | | | | |
| S Cancri | 8 38.2 | +19 24 | 8.2—10 | 9 11.6 | 8 7; | 17 18; | 27 6 | | | | | |
| RX Hydrae | 9 0.8 | − 7 52 | 9.1—10.5 | 2 6.8 | 5 13; | 14 16; | 23 19 | | | | | |
| S Antliae | 27.9 | −28 11 | 6.3— 6.8 | 0 07.8 | 1 2; | 7 13; | 20 12; | 27 0 | | | | |
| S Velorum | 29.4 | −44 46 | 7.8— 9.3 | 5 22.4 | 6 4; | 12 3; | 23 23; | 29 22 | | | | |
| Y Leonis | 9 31.1 | +26 41 | 9.3—11.2 | 1 16.5 | 4 17; | 13 3; | 21 13; | 30 0 | | | | |
| RR Velorum | 10 17.8 | −41 36 | 10.0—10.9 | 1 20.5 | 3 21; | 13 3; | 22 10 | | | | | |
| SS Carinae | 10 54.2 | −61 23 | 12.2—12.8 | 3 07.2 | 2 17; | 9 7; | 22 12; | 29 2 | | | | |
| ST Urs. Maj. | 11 22.4 | +45 44 | 6.7— 7.2 | 8 19.2 | 4 5; | 13 0; | 21 19; | 30 14 | | | | |
| RW Urs. Maj. | 35.4 | +52 34 | 10.3—11.4 | 7 07.9 | 7 20; | 15 4; | 22 12; | 29 19 | | | | |
| Z Draconis | 11 39.8 | +72 49 | 9.9—13.6 | 1 08.6 | 5 0; | 11 19; | 18 14; | 25 9 | | | | |
| RZ Centauri | 12 55.6 | −64 05 | 8.5— 8.9 | 1 21.0 | 7 11; | 14 23; | 22 11; | 29 23 | | | | |
| SS Centauri | 13 07.2 | −63 37 | 8.8—10.4 | 2 11.5 | 5 11; | 12 22; | 20 8; | 27 19 | | | | |
| δ Librae | 14 55.6 | − 8 07 | 4.8— 6.2 | 2 07.9 | 5 22; | 12 22; | 19 21; | 26 21 | | | | |
| U Coronae | 15 14.1 | +32 01 | 7.6— 8.7 | 3 10.9 | 5 23; | 12 20; | 19 18; | 26 16 | | | | |
| TW Draconis | 32.4 | +64 14 | 7.3— 8.9 | 2 19.4 | 3 7; | 11 17; | 20 3; | 28 13 | | | | |
| SS Librae | 15 43.4 | −15 14 | 9.3—11.5 | 0 18.4 | 5 22; | 13 13; | 21 5; | 28 21 | | | | |

**Minima of Variable Stars of Short Period.**—Continued.

| Star | R. A. 1900 | Decl. 1900 | Magnitude | Approx. Period | Greenwich mean time of minima in 1914 June |
|---|---|---|---|---|---|
| | h m | ° ′ | | d h | d h d h d h d h |
| SW Ophiuchi | 16 11.1 | — 6 44 | 9.2—10.0 | 2 10.7 | 7 17; 15 1; 22 9; 29 17 |
| SX Ophiuchi | 12.6 | — 6 25 | 10.5—11.2 | 2 01.5 | 1 5; 9 11; 17 17; 25 23 |
| R Arae | 31.1 | −56 48 | 6.8— 7.9 | 4 10.2 | 7 4; 16 1; 24 21 |
| TT Herculis | 16 49.9 | +17 00 | 8.9— 9.3 | 20 18.1 | 6 22; 17 23; 27 16 |
| TU Herculis | 17 09.8 | +30 50 | 9.5—12 | 2 06.4 | 7 11; 14 6; 21 2; 27 21 |
| U Ophiuchi | 11.5 | + 1 19 | 6.0— 6.7 | 0 20.1 | 8 19; 17 4; 25 14 |
| *u* Herculis | 13.6 | +33 12 | 4.6— 5.4 | 2 01.2 | 3 17; 9 21; 22 4; 28 8 |
| TX Herculis | 15.4 | +42 00 | 8.3— 9.0 | 1 00.7 | 2 17; 9 21; 17 2; 24 7 |
| RV Ophiuchi | 29.8 | + 7 19 | 9. —12 | 3 16.5 | 7 23; 15 8; 22 17; 30 2 |
| SZ Herculis | 36.0 | +33 01 | 9.5—10.3 | 0 19.6 | 2 20; 11 1; 19 5; 27 9 |
| TX Scorpii | 48.6 | −34 13 | 7.5— 8.2 | 0 22.6 | 4 15; 12 4; 19 17; 27 6 |
| UX Herculis | 49.7 | +16 57 | 8.8—10.5 | 1 13.2 | 4 11; 12 5; 19 23; 27 16 |
| Z Herculis | 53.6 | +15 09 | 7.1— 7.9 | 3 23.8 | 1 7; 9 7; 17 6; 25 6 |
| WX Sagittae | 53.6 | —17 24 | 9.2—10.8 | 2 03.1 | 4 8; 12 20; 21 9; 29 21 |
| WY Sagittae | 17 54.9 | —23 1 | 9.5—10.6 | 4 16.0 | 9 16; 19 0; 28 8 |
| SX Draconis | 18 03.0 | +58 23 | 9.3—10.5 | 5 04.1 | 1 21; 12 5; 22 13 |
| RS Sagittarii | 11.0 | −34 08 | 5.9— 6.3 | 2 10.0 | 7 18; 15 0; 22 6; 29 12 |
| V Serpentis | 11.1 | −15 34 | 9.5—11.1 | 3 10.9 | 3 3; 10 1; 23 21; 30 18 |
| RZ Scuti | 21.1 | — 9 15 | 7.4— 8.3 | 15 03.2 | 6 2; 21 5 |
| RZ Draconis | 21.8 | + 58 50 | 9.5—10.2 | 0 13.2 | 1 12; 9 19; 18 1; 26 7 |
| RX Herculis | 26.0 | +12 32 | 7.0— 7.6 | 0 21.3 | 9 13; 18 11; 27 8 |
| SX Sagittarii | 39.7 | −30 36 | 8.7— 9.8 | 2 01.8 | 7 3; 15 10; 23 18 |
| RR Draconis | 40.8 | +62 34 | 9.3—13 | 2 19.9 | 4 2; 12 14; 21 2; 29 13 |
| RS Scuti | 43.7 | −10 21 | 9.3—10.3 | 0 15.9 | 3 6; 9 21; 23 4; 29 20 |
| *β* Lyrae | 46.4 | +33 15 | 3.4— 4.1 | 12 21.8 | 4 23; 17 21; 30 19 |
| U Scuti | 18 48.9 | −12 44 | 9.1— 9.6 | 0 22.9 | 8 19; 18 9; 27 22 |
| RX Draconis | 19 01.1 | +58 35 | 9.3—10.2 | 1 21.4 | 7 1; 14 15; 22 5; 29 19 |
| RV Lyrae | 12.5 | +32 15 | 11. —12.8 | 3 14.4 | 2 13; 9 17; 16 22; 24 3 |
| RS Vulpec. | 13.4 | +22 16 | 6.9— 8.0 | 4 11.4 | 8 23; 17 22; 26 21 |
| U Sagittae | 14.4 | +19 26 | 6.5— 9.0 | 3 09.1 | 7 7; 14 1; 20 19; 27 13 |
| Z Vulpec. | 17.5 | +25 23 | 7.3— 8.5 | 2 10.9 | 7 0; 14 8; 21 17; 29 2 |
| TT Lyrae | 24.3 | +41 30 | 9.3—11.6 | 5 05.8 | 4 22; 10 4; 20 16; 25 21 |
| UZ Draconis | 26.1 | + 68 44 | 9.0— 9.8 | 1 15.1 | 2 23; 9 12; 22 13; 29 2 |
| SY Cygni | 19 42.7 | +32 28 | 10 —12 | 6 00.2 | 6 17; 12 17; 24 18; 30 18 |
| WW Cygni | 20 00.6 | +41 18 | 9.3—13.4 | 3 07.6 | 1 18; 8 9; 21 16; 28 7 |
| SW Cygni | 03.8 | +46 01 | 9. —11.7 | 4 13.8 | 8 20; 18 0; 27 3 |
| VW Cygni | 11.4 | +34 12 | 9.8—11.8 | 8 10.3 | 1 14; 10 0; 18 11; 26 21 |
| RW Capric. | 12.2 | −17 59 | 8.8—10.6 | 3 09.4 | 4 4; 10 23; 17 18; 24 13 |
| UW Cygni | 19.6 | +42 55 | 10.5—13 | 3 10.8 | 3 3; 10 1; 23 20; 30 18 |
| V Vulpec. | 32.3 | +26 15 | 8.2—9.8 | 37 19.0 | 19 18 |
| W Delphini | 33.1 | +17 56 | 9.4—12.1 | 4 19.4 | 4 17; 14 8; 23 22 |
| RR Delphini | 38.9 | +13 35 | 10.5—11.8 | 4 14.4 | 5 21; 15 2; 24 7 |
| Y Cygni | 48.1 | +34 17 | 7.1— 7.9 | 1 12.0 | 3 11; 10 23; 18 11; 25 23 |
| WZ Cygni | 49.3 | +38 27 | 9.9—10.8 | 0 14.0 | 6 6; 12 2; 23 19; 29 15 |
| RR Vulpec. | 20 50.5 | +27 32 | 9.6—11.0 | 5 01.2 | 3 7; 13 9; 23 12 |
| VV Cygni | 21 02.3 | +45 23 | 12.1—13.8 | 1 11.4 | 7 3; 14 13; 21 22; 29 7 |
| AE Cygni | 09.0 | +30 20 | 10.8—11.4 | 0 23.3 | 4 17; 14 9; 24 2 |
| RY Aquarii | 14.8 | —11 14 | 8.8—10.4 | 1 23.2 | 7 5; 15 2; 22 22; 30 19 |
| UZ Cygni | 55.2 | +43 52 | 8.9—11.6 | 31 07.3 | 30 3 |
| RT Lacertae | 21 57.4 | +43 24 | 9.1—10.5 | 5 01.7 | 2 20; 12 23; 23 3 |
| RW Lacertae | 22 40.6 | +49 08 | 10.2—11.2 | 5 04.4 | 1 10; 6 15; 17 0; 27 9 |
| X Lacertae | 22 45.0 | +55 54 | 8.2— 8.6 | 5 10.6 | 2 10; 7 20; 18 17; 29 15 |
| TT Androm. | 23 08.7 | +45 36 | 11.3—12.6 | 2 18.3 | 9 2; 17 9; 25 16 |
| Y Piscium | 29.3 | + 7 22 | 9.0—12.0 | 3 18.4 | 3 7; 10 20; 18 9; 25 21 |
| TW Androm. | 23 58.2 | +32 17 | 8.6—11.5 | 4 02.9 | 2 8; 10 13; 18 19; 27 1 |

## COMET AND ASTEROID NOTES.

**New Comet 1914 *a* (Kritzinger).**—A new comet was discovered by Kritzinger, at Bothkamp, Germany, on March 29, in the northern part of the constellation Scorpio. It was described as visible in a small telescope and moving northeast. The comet was looked up at Goodsell Observatory on the night of April 1.

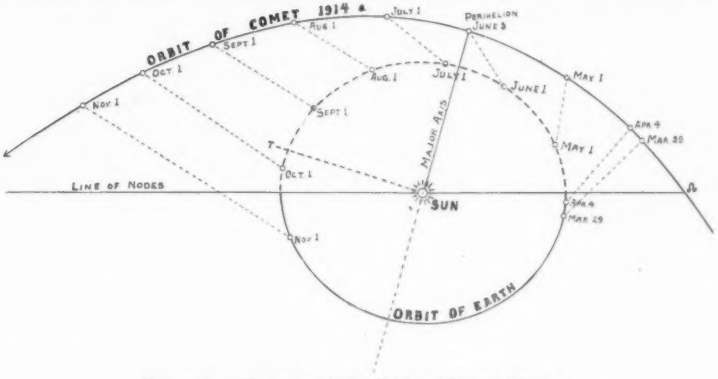



FIGURE 1. Diagram of the Orbit of Comet 1914 *a*.

It was then easily visible but quite faint and diffuse in our 5-inch finder; round, about 5′ in diameter, with slight condensation in center. In the 16-inch telescope it was faint but the nuclear condensation was sufficient for fair measures of position. On April 4 it was exceedingly faint in moonlight, but we succeeded in finding it and obtained a fair measure of position. The following observations of the position of the comet are all that have come to hand at the time of this writing (April 21):

| Gr.M.T | App. $\alpha$ | App. $\delta$ | Observer | Place |
|---|---|---|---|---|
| 1914 | h m s | ° ′ ″ | | |
| March 29.6171 | 16 11 39.2 | −9 30 45 | Kritzinger | Bothkamp |
| 30.5781 | 16 14 36.5 | −9 01 07 | Palisa | Vienna |
| 30.7898 | 16 15 15.8 | −8 54 14 | | Cordoba |
| 30.8301 | 16 15 22.9 | −8 53 08 | | Washington |
| April 1.8697 | 16 21 47.4 | −7 45 50 | Wilson | Northfield |
| 1.9356 | ... | −7 43 20* | Haynes | Mt. Hamilton |
| 1.9442 | 16 21 59.6* | ... | Haynes | Mt. Hamilton |
| 4.7907 | 16 31 16.9 | −6 00 14 | Wilson | Northfield |
| 15.7687 | 17 10 06.8 | +2 16 38 | Wilson | Northfield |
| 20.7672 | 17 30 35.1 | +6 50 32 | Wilson | Northfield |

From the observations at Bothkamp, March 29, Vienna March 30 and Mount Hamilton April 1, the following elements and ephemeris were computed by Professor R. T. Crawford and Miss Sophia H. Levy, of the Berkeley Astronomical Department, and published in the *Lick Observatory Bulletin* No. 253.

ELEMENTS OF COMET 1914 *a* BY PROFESSOR CRAWFORD AND MISS LEVY.

$T = 1914$ May 31.337 Gr. M. T.
$\omega = 67° 12'.9$
$\Omega = 198\ 40\ .0$
$i = 23\ 36\ .3$
$q = 1.25374$

* Mean place 1914.0.

EPHEMERIS FOR GREENWICH MIDNIGHT.

| 1914 | | True α | True δ | log Δ | Brightness |
|---|---|---|---|---|---|
| | | h m s | ° ′ | | |
| April | 3.5 | 16 27 01 | −6 48.4 | 9.8502 | 1.18 |
| | 5.5 | 33 33 | 5 34.0 | | |
| | 7.5 | 40 15 | 4 14.7 | 9.8238 | 1.39 |
| | 9.5 | 47 06 | 2 50.7 | | |
| | 11.5 | 16 54 05 | −1 22.1 | 9.7990 | 1.63 |
| | 13.5 | 17 01 13 | +0 10.9 | | |
| | 15.5 | 08 30 | 1 48.3 | 9.7764 | 1.89 |
| | 17.5 | 15 55 | 3 29.6 | | |
| | 19.5 | 17 23 28 | +5 14.5 | 9.7565 | 2.15 |

From the observations at Bothkamp March 29 and at Northfield April 1 and 4 elements have been computed by Professors Wilson and Gingrich, which represent later observations considerably closer than those above, although the error of representation of the middle place is −15″ in R. A.

ELEMENTS OF COMET 1914 *a* BY WILSON AND GINGRICH.

$T = 1914$ June 5.1848 Gr.M.T.
$\omega = 73° 40' 29''$
$\Omega = 198 \ 56 \ 45$
$i = 23 \ 58 \ 43$
$\log q = 0.072714$

EPHEMERIS COMPUTED BY C. H. GINGRICH.

| 1914 | | True α | True δ | log r | log Δ | Brightness |
|---|---|---|---|---|---|---|
| | | h m s | ° ′ | | | |
| May | 1.5 | 18 19 09.1 | +17 56.7 | 0.1144 | 9.6975 | 3.54 |
| | 2.5 | 23 53.9 | 18 58.9 | | | |
| | 3.5 | 28 40.9 | 20 00.6 | | | |
| | 4.5 | 33 29.9 | 21 01.8 | | | |
| | 5.5 | 38 20.9 | 22 02.5 | 0.1061 | 9.6913 | 3.77 |
| | 6.5 | 43 13.9 | 23 02.4 | | | |
| | 7.5 | 48 08.8 | 24 01.4 | | | |
| | 8.5 | 53 05.1 | 24 59.5 | | | |
| | 9.5 | 18 58 02.9 | 25 56.5 | 0.0985 | 9.6898 | 3.93 |
| | 10.5 | 19 03 02.0 | 26 52.3 | | | |
| | 11.5 | 08 01.9 | 27 47.0 | | | |
| | 12.5 | 13 02.4 | 28 40.4 | | | |
| | 13.5 | 18 03.2 | 29 32.5 | 0.0917 | 9.6922 | 4.01 |
| | 14.5 | 23 04.0 | 30 23.1 | | | |
| | 15.5 | 28 04.9 | 31 12.2 | | | |
| | 16.5 | 33 05.3 | 31 59.8 | | | |
| | 17.5 | 38 05.3 | 32 45.9 | 0.0858 | 9.6981 | 4.01 |
| | 18.5 | 43 04.4 | 33 30.4 | | | |
| | 19.5 | 48 02.5 | 34 13.3 | | | |
| | 20.5 | 52 59.4 | 34 54.6 | | | |
| | 21.5 | 19 57 54.7 | 35 34.3 | 0.0809 | 9.7066 | 3.95 |
| | 22.5 | 20 02 48.5 | 36 12.4 | | | |
| | 23.5 | 07 40.5 | 36 48.9 | | | |
| | 24.5 | 12 29.6 | 37 23.9 | | | |
| | 25.5 | 20 17 16.3 | 37 57.3 | 0.0771 | 9.7170 | 3.83 |
| | 26.5 | 22 00.4 | 38 29.0 | | | |
| | 27.5 | 26 41.3 | 38 59.3 | | | |
| | 28.5 | 31 19.5 | 39 28.1 | | | |
| | 29.5 | 35 54.7 | 39 55.4 | 0.0744 | 9.7286 | 3.67 |
| | 30.5 | 40 26.6 | 40 21.3 | | | |
| | 31.5 | 44 55.5 | 40 45.8 | | | |
| June | 1.5 | 49 21.3 | 41 09.0 | | | |
| | 2.5 | 20 53 44.0 | +41 30.8 | 0.0730 | 9.7408 | 3.50 |

The diagram, Figure 1, was prepared according to the elements by Wilson and Gingrich. It shows at a glance the relation of the comet's path to that of the earth and it is evident that the position of the comet is favorable to observation all through the summer. It will be nearest the earth during May and will reach its greatest theoretical brightness about the middle of the month. At brightest according to the ephemeris, it will be 4.01 times as bright as on the date of discovery. This, however, will not make it a very conspicuous object and it will require a telescope to make it visible.

FIGURE 2. Diagram showing the Apparent Path of Comet 1914 *a* among the Stars during May.

The diagram, Figure 2, shows the apparent course of the comet through the constellations Ophiuchus, Hercules, Lyra and Cygnus, and will enable the amateur with a telescope of three or four inches to find the stranger readily.

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**Comet 1913 *f* (Delavan).**—Mr. F. E. Seagrave has calculated the following parabolic elements of Delavan's comet from observations made at Goodsell Observatory on the dates December 20, January 21 and February 20. They agreee very closely with the elements obtained by Einarsson and Nicholson, given in POPULAR ASTRONOMY for March 1914.

$$\begin{aligned} T &= 1914\ \text{Oct.}\ 26.6731 \\ \omega &= 97^\circ\ 26'\ 31''.1 \\ \Omega &= 59\ \ 09\ \ 33\ \ .4 \\ i &= 68\ \ 07\ \ 34\ \ .8 \\ \log q &= 0.04375 \end{aligned}$$

From these elements Mr. Seagrave has calculated the following ephemeris of the comet, which agrees quite closely with that given in our March number (page 185) and therefore probably indicates very nearly the course which the comet will take through the constellations in the coming autumn. During the greater part of August

and September it will be circumpolar, i.e. it will be above the horizon day and night in our latitude and so, although it will be low in the north in the evening, it may be seen most of the night. It will be most favorably situated for observation in the hours after midnight when it will be seen toward the northeast. During September it will be passing eastward through the southern Ursa Major or 'The Great Bear', a constellation with which every one is familiar, so that if the comet becomes visible to the naked eye, as it probably will, all may know where to look for it. On October 26 it will be about 7° north of the star Arcturus.

EPHEMERIS OF DELAVAN'S COMET BASED UPON ABOVE ELEMENTS.

| 1914 | $\alpha$ h m s | $\delta$ ° ′ ″ | log $r$ | log $\Delta$ |
|---|---|---|---|---|
| Aug. 23 | 7 31 14 | +46 22 16 | 0.17697 | 0.29580 |
| 31 | 8 15 43 | +48 35 9 | 0.15341 | 0.26693 |
| Sept. 8 | 9 8 35 | +49 55 58 | 0.13015 | 0.24070 |
| 16 | 10 8 6 | +49 51 14 | 0.10785 | 0.21914 |
| 24 | 11 9 33 | +47 55 39 | 0.08733 | 0.20434 |
| Oct. 2. | 12 7 1 | +44 9 20 | 0.06961 | 0.19783 |
| 10 | 12 56 44 | +38 56 4 | 0.05579 | 0.19996 |
| 18 | 13 37 56 | +32 56 34 | 0.04693 | 0.20978 |
| 26 | 14 11 50 | +26 44 39 | 0.04383 | 0.22528 |

When nearest the earth on October 2 the comet's distance from us will be 1.577 astronomical units, or more than half as far again as the sun.

Mr. Seagrave calls attention to the great brightness which this comet must have, to have been discovered at such a great distance from the sun. "When discovered last December it was 9,000,000 miles farther from the sun than Encke's comet is when at aphelion. It was three months farther from perihelion passage than Halley's comet was when discovered in September 1909, and at the same time over three magnitudes brighter. The perihelion distance being a little greater than our distance from the sun will of course offset this somewhat, as regards its making a fine display next summer and autumn."

## NOTES FOR OBSERVERS.

**Monthly Report of the American Association of Variable Star Observers, March-April, 1914.**—Inasmuch as our efforts are now being especially directed to the observation of the neglected variables, which are for the most part faint and difficult of observation in small telescopes, a decrease in the number of positive observations made each month is to be expected, but as efficiency of service, and quality as regards the estimates is of far more importance and consideration than the number of observations made, we have every reason to be satisfied with the progress we are making.

Of the neglected variables 26 have been observed during the past month and 127 observations secured. This good showing is largely due to the efforts of Miss Young, and Messrs. Bancroft and Gray.

It is a pleasure to announce that Mr. William H. Nelson, of Manati, Porto Rico has recently joined the Association. We are glad of an observer in that region as the more spread out we are territorially the better work we can do as an organisation as in such a case adverse weather conditions have least effect in preventing continuous work. Mr. Nelson's observations will be designated "N" in the reports to which he contributes.

VARIABLE STAR OBSERVATIONS Mar.-Apr., 1914.

001726
T Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 10.2 | Y |
| | 10 | 10.0 | Bu |
| | 17 | 10.2 | Bu |

001755
T Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 9.0 | Ba |
| | 10 | 9.1 | B |
| | 10 | 9.8 | Bu |
| | 17 | 10.0 | Bu |
| | 20 | 9.6 | Ba |
| | 23 | 9.9 | B |

001838
R Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 10 | 7.4 | Bu |
| | 17 | 7.6 | Bu |

003179
Y Cephei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 10.1 | Ba |
| | 15 | 10.6 | Ba |
| | 20 | 10.9 | Ba |
| | 23 | 11.1 | Ba |
| | 26 | 11.2 | Ba |

004047
U Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 2 | 10.6 | L |
| | 7 | 10.1 | Ba |
| | 10 | 9.1 | B |
| | 13 | 10.2 | L |
| | 15 | 9.7 | Ba |
| | 17 | 9.7 | Y |
| | 20 | 9.3 | Ba |
| | 23 | 8.8 | B |

004132
RW Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 10 | 9.6 | Bu |
| | 17 | 9.6 | Bu |

004746
RV Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 10.6 | Ba |
| | 15 | 10.7 | Ba |
| | 20 | 10.7 | Ba |

004958
W Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 10.0 | Ba |
| | 13 | 9.6 | O |
| | 15 | 9.2 | Ba |
| | 17 | 10.0 | Br |
| | 20 | 9.3 | Ba |
| | 21 | 10.1 | Br |
| | 22 | 9.2 | Ba |
| | 23 | 9.0 | Ba |
| | 24 | 8.9 | Ba |
| | 26 | 9.0 | Ba |

012350
RZ Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 15 | 12.4 | Ba |
| | 20 | 11.8 | Ba |
| | 24 | 11.6 | Ba |

014958
X Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 17 | 10.3 | Ba |
| | 10 | 10.6 | Bu |
| | 10 | 10.5 | Ba |
| | 17 | 9.7 | Y |
| | 17 | 10.8 | Bu |
| | 20 | 10.6 | Ba |
| | 24 | 10.5 | Ba |
| | 28 | 11.1 | Bb |
| | 31 | 11.2 | Bb |

015354
U Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 7.6 | Ba |
| | 10 | 8.2 | Bu |
| | 15 | 7.6 | Ba |
| | 17 | 8.0 | Y |
| | 17 | 8.0 | Bu |
| | 20 | 7.8 | Ba |
| | 23 | 7.9 | Ba |
| | 26 | 7.9 | Ba |

021024
R Arietis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 1 | 8.0 | G |
| | 10 | 8.0 | Bu |
| | 13 | 8.5 | St |
| | 14 | 8.6 | G |
| | 17 | 8.0 | St |
| | 17 | 8.2 | Bu |
| | 18 | 8.2 | Br |
| | 20 | 8.5 | Br |
| | 21 | 8.5 | Br |
| | 22 | 8.5 | Br |

021258
T Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 10 | 9.0 | Bu |
| | 17 | 9.4 | Bu |

*021403*
*o* Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 2 | 28 | 3.1 | R |
| 3 | 1 | 3.1 | G |
| | 4 | 2.9 | R |
| | 4 | 3.0 | G |
| | 5 | 3.0 | L |
| | 5 | 3.0 | G |
| | 7 | 3.3 | R |
| | 8 | 3.1 | R |
| | 9 | 3.1 | L |
| | 10 | 3.0 | Bu |
| | 12 | 3.2 | R |
| | 13 | 3.3 | L |
| | 14 | 3.2 | G |
| | 14 | 2.8 | Bb |

*o* Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 16 | 3.2 | L |
| | 17 | 3.3 | R |
| | 17 | 3.5 | St |
| | 17 | 2.8 | Bu |
| | 25 | 3.4 | Bb |

021558
S Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 10.7 | Ba |
| | 10 | 10.8 | Bu |
| | 15 | 11.0 | Ba |
| | 17 | 10.6 | B |
| | 17 | 10.6 | Bu |
| | 20 | 11.0 | Ba |
| | 24 | 10.9 | B |
| | 26 | 11.0 | Ba |

022000
R Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 13 | 8.9 | Y |

023133
R Trianguli

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 1 | 8.5 | G |
| | 6 | 8.8 | G |
| | 7 | 9.1 | Ba |
| | 10 | 9.3 | Bu |
| | 13 | 9.4 | O |
| | 14 | 9.2 | G |
| | 15 | 9.4 | Ba |
| | 17 | 9.3 | Bu |
| | 17 | 9.4 | B |
| | 17 | 9.4 | O |
| | 19 | 9.5 | O |
| | 20 | 9.6 | Ba |
| | 23 | 9.4 | G |
| | 24 | 9.8 | Ba |

024356
W Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 9.0 | Ba |
| | 7 | 9.4 | G |
| | 10 | 9.4 | Bu |
| | 14 | 9.6 | G |
| | 15 | 9.0 | Ba |
| | 17 | 9.4 | Bu |
| | 17 | 9.2 | Hu |
| | 18 | 9.7 | L |
| | 19 | 9.5 | O |
| | 20 | 9.5 | P |
| | 20 | 9.0 | Ba |
| | 23 | 9.1 | Ba |
| | 26 | 9.0 | Ba |
| | 27 | 9.4 | G |

030514
U Arietis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 8.5 | Ba |
| | 10 | 8.4 | Bu |
| | 15 | 8.6 | Ba |
| | 17 | 8.6 | Bu |
| | 20 | 8.7 | Ba |
| | 24 | 9.0 | Ba |

032043
Y Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 6 | 9.0 | G |
| | 7 | 9.4 | Ba |
| | 10 | 9.6 | Bu |
| | 13 | 9.7 | O |
| | 14 | 9.2 | G |
| | 15 | 9.1 | Ba |
| | 17 | 9.8 | Bu |
| | 17 | 8.5 | Hu |
| | 20 | 9.3 | P |
| | 20 | 8.6 | Ba |
| | 23 | 9.1 | G |
| | 24 | 8.7 | Ba |
| | 24 | 8.5 | B |
| | 26 | 8.7 | Ba |

032335
R Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 9.7 | Ba |
| | 13 | 11.3 | Y |
| | 15 | 10.6 | Ba |
| | 20 | 10.6 | Ba |
| | 24 | 10.8 | Ba |

033362
U Camelop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 6.8 | Ba |
| | 10 | 6.8 | Bu |
| | 15 | 7.0 | Ba |
| | 17 | 6.8 | Bu |
| | 18 | 7.4 | Br |
| | 19 | 7.5 | Br |
| | 20 | 7.5 | Br |
| | 22 | 7.0 | Ba |
| | 24 | 7.1 | Ba |

042215
W Tauri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 5 | 10.2 | B |
| | 7 | 10.7 | Ba |
| | 10 | 10.5 | B |
| | 13 | 10.1 | Y |
| | 13 | 10.8 | B |
| | 15 | 11.0 | Ba |
| | 15 | 10.7 | G |
| | 17 | 10.9 | Hu |
| | 20 | 10.9 | B |
| | 20 | 11.2 | Ba |
| | 22 | 10.9 | Hu |
| | 23 | 11.1 | B |
| | 24 | 11.2 | Ba |

043065
T Camelop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 17 | 9.2 | Y |

043208
RX Tauri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 5 | 9.2 | B |
| | 7 | 9.2 | Ba |
| | 10 | 9.3 | B |
| | 11 | 9.4 | Bu |
| | 13 | 9.6 | O |
| | 13 | 9.3 | B |
| | 14 | 9.5 | Bb |
| | 15 | 9.6 | Bb |
| | 15 | 9.6 | Ba |
| | 19 | 9.8 | O |
| | 20 | 9.9 | P |
| | 20 | 9.6 | Ba |
| | 20 | 9.4 | B |
| | 22 | 9.9 | Bb |
| | 23 | 9.9 | B |
| | 24 | 10.0 | O |
| | 24 | 10.0 | Hu |
| | 24 | 10.0 | Bb |
| | 24 | 10.1 | Ba |
| | 25 | 10.1 | Bb |
| | 26 | 9.8 | Bu |
| | 28 | 10.2 | Bb |
| | 31 | 10.2 | Bb |

043274
X Camelop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 12 | 9.9 | O |
| | 13 | 9.9 | O |
| | 15 | 9.8 | O |
| | 16 | 10.0 | G |
| | 17 | 9.8 | Y |
| | 17 | 9.6 | O |
| | 19 | 9.5 | O |
| | 22 | 9.2 | O |
| | 23 | 9.5 | G |
| | 24 | 9.0 | O |
| | 24 | 8.5 | Ba |
| 4 | 3 | 8.0 | O |

044617
V Tauri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 11 | 10.0 | Y |
| | 13 | 9.9 | B |
| | 13 | 10.3 | V |
| | 15 | 10.4 | Ba |
| | 19 | 10.6 | Y |
| | 20 | 10.4 | B |
| | 22 | 10.9 | Ba |
| | 23 | 11.1 | B |
| | 25 | <11.1 | V |
| | 26 | 11.9 | Ba |

045307
R Orionis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 8 | 9.4 | Ba |
| | 15 | 9.7 | Ba |
| | 16 | 10.0 | Y |
| | 20 | 10.0 | O |
| | 20 | 9.5 | Ba |
| | 24 | 9.5 | Ba |
| | 26 | 9.8 | G |

VARIABLE STAR OBSERVATIONS Mar.-Apr., 1914.—Continued.

*045514*
R Leporis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 1 | 7.7 | G |
| | 4 | 7.4 | G |
| | 6 | 7.2 | G |
| | 7 | 7.2 | G |
| | 8 | 7.2 | Ba |
| | 9 | 7.1 | L |
| | 11 | 7.4 | Bu |
| | 11 | 7.5 | G |
| | 14 | 7.5 | G |
| | 15 | 8.4 | C |
| | 15 | 7.1 | Ba |
| | 16 | 7.3 | L |
| | 16 | 8.7 | C |
| | 17 | 8.8 | C |
| | 17 | 7.6 | B |
| | 22 | 7.1 | Ba |
| | 26 | 7.2 | Bu |
| | 26 | 7.4 | G |

050001
W Orionis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 1 | 6.1 | G |
| | 2 | 6.0 | G |
| | 15 | 6.2 | G |
| | 23 | 5.9 | G |

*050022*
T Leporis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 3 | 10.6 | G |
| | 5 | 10.5 | G |
| | 15 | 10.6 | G |
| | 26 | 10.6 | G |

050953
R Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 2 | 8.1 | G |
| | 6 | 8.1 | M |
| | 7 | 8.4 | G |
| | 8 | 8.3 | Ba |
| | 11 | 8.2 | Bu |
| | 11 | 8.5 | G |
| | 12 | 8.0 | M |
| | 14 | 8.6 | G |
| | 15 | 8.5 | Ba |
| | 17 | 8.5 | B |
| | 18 | 8.7 | G |
| | 20 | 8.7 | G |
| | 20 | 8.5 | Ba |
| | 23 | 8.5 | Ba |
| | 23 | 8.6 | B |
| | 26 | 8.0 | Bu |
| | 26 | 8.6 | Ba |
| | 26 | 8.8 | G |
| 4 | 5 | 9.4 | P |

052034
S Aurigæ

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 8 | 9.2 | Ba |
| | 13 | 9.2 | B |
| | 15 | 9.3 | Ba |
| | 16 | 10.0 | L |
| | 17 | 9.2 | Y |
| | 22 | 9.3 | Ba |
| | 23 | 9.3 | B |
| | 24 | 9.1 | Ba |

052036
W Aurigæ

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 8 | 10.9 | Ba |
| | 15 | 11.1 | Ba |
| | 22 | 11.4 | Ba |
| | 24 | 12.0 | B |
| | 24 | 11.6 | Ba |

*052404*
S Orionis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 14 | 11.3 | Bb |
| | 15 | 11.2 | Bb |
| | 15 | 12.8 | Ba |
| | 18 | 12.1 | L |
| | 20 | 12.4 | Ba |
| | 24 | 11.0 | Bb |
| | 25 | 11.0 | Bb |
| | 26 | 12.3 | Ba |
| | 28 | 11.0 | Bb |
| | 31 | 11.1 | Bb |

*053005a*
T Orionis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 9.9 | G |
| | 7 | 10.0 | Ba |
| | 14 | 10.2 | G |
| | 15 | 9.9 | Ba |
| | 20 | 10.4 | Ba |
| | 23 | 10.5 | G |
| | 24 | 10.0 | Ba |

053531
U Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 11 | 11.4 | Y |
| | 16 | 11.2 | Y |
| | 22 | 12.9 | Ba |

054920
U Orionis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 2 | 10.6 | L |
| | 7 | 10.0 | Ba |
| | 14 | 10.6 | L |
| | 15 | 10.2 | Ba |
| | 16 | 10.2 | Y |
| | 17 | 10.0 | Hu |
| | 20 | 10.0 | Ba |
| | 22 | 10.0 | Hu |
| | 24 | 9.8 | Ba |
| | 24 | 10.2 | Hu |
| | 26 | 10.0 | S |

054974
V Camelop

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 24 | 13.1 | B |

055353
Z Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 16 | 11.0 | Y |

*060124*
Z Leporis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 5 | 6.5 | G |
| | 14 | 6.5 | G |

060450
X Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 8 | 8.4 | Ba |
| | 10 | 8.4 | B |
| | 11 | 8.5 | Bu |
| | 13 | 8.1 | V |
| | 15 | 8.6 | Ba |
| | 17 | 8.8 | Y |
| | 23 | 8.1 | V |
| | 22 | 8.5 | Ba |
| | 24 | 8.6 | Ba |
| | 26 | 8.5 | Bu |

061647
V Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 14 | 10.2 | V |
| | 17 | 10.2 | Y |
| | 25 | 10.3 | V |
| | 26 | 10.3 | Ba |

*061702*
V Monoc.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 1 | 6.7 | G |
| | 11 | 7.7 | G |
| | 15 | 7.0 | Ba |
| | 22 | 7.5 | Bu |
| | 23 | 7.8 | G |
| | 26 | 7.5 | Ba |

063159
U Lyncis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 15 | 12.0 | Ba |
| | 20 | 11.6 | Ba |
| | 23 | 11.4 | Ba |
| | 26 | 11.0 | Ba |

063558
S Lyncis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 15 | 13.1 | Ba |
| | 17 | 12.8 | Y |
| | 20 | 12.8 | Ba |
| | 23 | 12.6 | Ba |
| | 26 | 12.5 | Ba |

064030
X Geminorum

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 13 | 9.5 | Y |
| | 13 | 9.9 | V |
| | 15 | 9.3 | Ba |
| | 22 | 9.2 | Ba |
| | 23 | 9.9 | V |
| | 26 | 9.1 | Ba |

064932
NOVA GEMIN. II

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 2 | 11.0 | L |
| | 16 | 11.1 | L |
| | 22 | 11.6 | Ba |

065111
Y Monoc.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 1 | 10.0 | G |
| | 13 | 11.0 | G |
| | 22 | 12.0 | Ba |
| | 26 | 11.9 | Ba |

*065208*
X Monoc.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 1 | 7.5 | G |
| | 4 | 7.4 | G |
| | 5 | 7.5 | G |
| | 7 | 7.5 | G |
| | 9 | 7.6 | L |
| | 11 | 7.6 | G |
| | 15 | 7.3 | Ba |
| | 16 | 7.4 | R |
| | 17 | 7.2 | R |
| | 19 | 7.9 | R |
| | 21 | 7.3 | R |
| | 22 | 7.5 | Ba |
| | 23 | 7.3 | G |
| | 24 | 7.5 | R |
| | 26 | 7.6 | Ba |

065355
R Lyncis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 11 | 7.4 | Bu |
| | 17 | 8.2 | Y |
| | 26 | 7.4 | Bu |

070122a
R Gemin.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 13 | 12.5 | Y |
| | 24 | 12.6 | Hu |

070310
R Can. Min.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 3 | 9.8 | G |
| | 13 | 10.5 | O |
| | 16 | 10.4 | L |
| | 17 | 10.3 | G |
| | 22 | 10.3 | Ba |
| | 24 | 10.5 | O |
| | 27 | 10.6 | G |

071713
V Gemin.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 13 | 8.5 | Y |
| | 16 | 8.8 | V |
| | 22 | 8.6 | Ba |
| | 25 | 8.8 | V |
| | 26 | 9.1 | Ba |

072708
S Can. Min.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 2 | 28 | 7.6 | R |
| 3 | 2 | 7.4 | R |
| | 2 | 7.4 | L |
| | 3 | 7.5 | R |
| | 3 | 7.4 | G |
| | 4 | 7.5 | R |
| | 5 | 7.5 | R |
| | 6 | 7.3 | G |
| | 6 | 7.6 | R |
| | 7 | 7.3 | R |
| | 8 | 7.4 | R |
| | 9 | 7.2 | R |
| | 11 | 7.5 | Bu |
| | 12 | 7.7 | O |
| | 12 | 7.5 | R |
| | 13 | 7.6 | G |
| | 13 | 7.8 | St |
| | 14 | 7.8 | St |
| | 16 | 8.1 | S |
| | 17 | 7.5 | R |
| | 17 | 7.7 | O |
| | 17 | 8.0 | St |
| | 17 | 7.8 | G |
| | 19 | 7.5 | R |
| | 20 | 7.7 | O |
| | 21 | 7.6 | R |
| | 22 | 7.9 | Ba |
| | 23 | 7.9 | G |
| | 24 | 7.7 | R |
| | 24 | 7.7 | O |
| | 24 | 8.0 | M |
| | 25 | 8.6 | St |
| | 26 | 8.0 | B |
| | 26 | 7.8 | Bu |
| | 26 | 8.0 | Ba |
| 4 | 5 | 8.5 | P |

072811
T Can. Min.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 13 | 9.7 | Y |
| | 20 | 10.6 | V |
| | 22 | 10.0 | Ba |
| | 26 | 10.5 | Ba |

073508
U Can. Min.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 2 | 11.4 | L |
| | 13 | 12.0 | Y |
| | 15 | 12.2 | Ba |
| | 22 | 12.4 | Ba |
| | 26 | 12.5 | B |

073723
S Gemin.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 13 | 11.8 | Y |
| | 22 | 12.3 | Ba |
| | 24 | 11.9 | Hu |
| | 26 | 12.0 | Ba |

VARIABLE STAR OBSERVATIONS Mar.-Apr., 1914—Continued

074323
T Gemin.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 13 | 8.7 | Y |
| | 16 | 8.8 | V |
| | 22 | 8.5 | Ba |
| | 25 | 8.5 | V |
| | 26 | 8.3 | Ba |

*080322*
RU Puppis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 18 | 9.6 | G |

081112
R Cancri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 6 | 10.2 | M |
| | 11 | 10.0 | Bu |
| | 14 | 10.4 | L |
| | 15 | 10.3 | Ba |
| | 17 | 10.0 | O |
| | 22 | 9.7 | Hu |
| | 23 | 10.2 | Ba |
| | 26 | 9.8 | Bu |

081617
V Cancri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 11 | 10.0 | Bu |
| | 22 | 12.2 | Ba |
| | 26 | 10.0 | Bu |
| | 26 | 12.2 | Ba |

081633
T Lyncis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 17 | 11.8 | G |
| | 24 | 12.6 | Hu |
| | 26 | 12.0 | G |

*082405*
RT Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 7.6 | G |
| | 7 | 7.5 | G |
| | 11 | 7.8 | Bu |
| | 13 | 7.5 | G |
| | 13 | 8.0 | O |
| | 14 | 7.7 | G |
| | 15 | 7.5 | Ba |
| | 16 | 7.4 | L |
| | 17 | 7.8 | O |
| | 18 | 7.8 | G |
| | 24 | 7.5 | Ba |
| | 25 | 7.8 | O |
| | 26 | 8.0 | Bu |
| | 26 | 7.8 | G |

083019
U Cancr

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 13 | 9.6 | Y |
| | 15 | 9.7 | Ba |
| | 16 | 9.7 | V |
| | 20 | 9.6 | Ba |
| | 26 | 10.2 | Ba |

084803
S Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 16 | 11.2 | G |
| | 17 | 12.0 | Hu |
| | 20 | 12.5 | B |
| | 24 | 12.0 | Hu |

*085008*
T Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 11 | 9.8 | Bu |
| | 13 | 9.5 | O |
| | 16 | 9.9 | G |
| | 16 | 9.6 | V |
| | 17 | 9.5 | O |
| | 18 | 9.6 | Br |
| | 22 | 9.2 | Ba |
| | 22 | 9.4 | O |
| | 25 | 9.4 | G |
| | 26 | 9.6 | Bu |
| | 26 | 9.3 | Ba |
| | 27 | 9.3 | G |

085120
T Cancri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 11 | 9.0 | Bu |
| | 15 | 8.1 | Ba |
| | 17 | 8.5 | O |
| | 24 | 8.4 | Hu |
| | 26 | 8.4 | Ba |
| | 26 | 9.4 | Bu |

090425
W Cancri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 13 | 12.6 | Y |
| | 15 | 12.1 | Ba |
| | 19 | 12.3 | Y |
| | 20 | 12.1 | Ba |
| | 23 | 11.7 | Ba |
| | 26 | 11.6 | Ba |

*093014*
X Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 17 | 11.5 | G |
| | 26 | 12.0 | Ba |
| | 27 | 11.4 | G |

093934
R Leo. Min.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 5 | 8.4 | G |
| | 6 | 9.1 | M |
| | 11 | 9.0 | Bu |
| | 12 | 8.9 | O |
| | 13 | 8.6 | G |
| | 14 | 8.7 | G |
| | 17 | 9.0 | O |
| | 21 | 9.5 | Br |
| | 22 | 9.3 | Ba |
| | 22 | 9.4 | O |
| | 24 | 8.9 | Hu |
| | 26 | 9.4 | Bu |
| | 26 | 9.3 | G |

094211
R Leonis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 2 | 5.9 | G |
| | 4 | 5.9 | G |
| | 5 | 6.2 | L |
| | 6 | 6.4 | M |
| | 7 | 6.1 | Ba |
| | 9 | 6.3 | L |
| | 11 | 6.6 | Bu |
| | 12 | 6.6 | O |
| | 13 | 6.8 | St |
| | 13 | 6.4 | B |
| | 13 | 6.1 | G |
| | 13 | 6.9 | E |
| | 14 | 6.1 | G |
| | 14 | 7.2 | Bb |
| | 14 | 6.8 | St |
| | 15 | 6.4 | Ba |
| | 15 | 7.0 | C |
| | 15 | 6.8 | Bb |
| | 15 | 6.6 | O |
| | 16 | 7.1 | S |
| | 16 | 6.8 | C |
| | 16 | 6.5 | L |
| | 17 | 6.8 | C |
| | 17 | 6.4 | G |
| | 18 | 6.8 | Br |
| | 19 | 6.6 | O |
| | 20 | 7.0 | Br |
| | 21 | 6.9 | Br |
| | 22 | 7.0 | Bb |
| | 23 | 6.6 | G |
| | 23 | 6.5 | Ba |
| | 23 | 6.6 | O |
| | 24 | 7.1 | M |
| | 24 | 7.1 | Bb |
| | 25 | 7.1 | Bb |
| | 26 | 6.6 | O |
| | 26 | 6.8 | Bu |
| | 28 | 7.3 | Bb |
| | 31 | 7.4 | Bb |

*094622*
Y Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 3 | 7.0 | G |
| | 14 | 6.6 | G |
| | 15 | 6.5 | Ba |
| | 15 | 6.4 | G |
| | 17 | 6.2 | G |
| | 18 | 6.2 | G |
| | 23 | 6.1 | G |
| | 26 | 6.1 | G |

095421
V Leonis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 6 | 9.6 | G |
| | 14 | 10.4 | G |
| | 20 | 12.3 | Ba |

*103012*
U Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 3 | 5.3 | G |
| | 11 | 5.4 | Bu |

U Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 14 | 5.2 | G |
| | 15 | 5.4 | G |
| | 15 | 5.0 | C |
| | 16 | 5.0 | C |
| | 17 | 4.9 | C |
| | 17 | 5.4 | G |
| | 23 | 5.3 | G |
| | 26 | 5.2 | G |
| | 26 | 6.0 | Bu |
| | 31 | 5.3 | H |

103769
R Urs. Maj.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 2 | 10.6 | G |
| | 4 | 12.1 | H |
| | 13 | 12.1 | Ba |
| | 14 | 11.2 | G |
| | 20 | 11.7 | Ba |
| | 23 | 11.3 | Ba |
| | 24 | 11.2 | B |
| | 26 | 11.1 | Ba |

*104620*
V Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 3 | 6.8 | G |
| | 13 | 7.6 | Y |
| | 14 | 6.8 | G |
| | 15 | 6.8 | Ba |
| | 23 | 6.5 | G |

*105517*
R Crateris

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 3 | 8.1 | G |
| | 14 | 8.5 | G |
| | 17 | 8.4 | G |
| | 23 | 8.0 | G |

120012
SU Virginis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 15 | 12.5 | Ba |

*120905*
T Virginis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 20 | 11.2 | Ba |
| | 24 | 10.4 | Ba |
| | 26 | 10.1 | Ba |

*121418*
R Corvi

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 17 | 12 5 | B |
| | 21 | 12.1 | B |
| | 24 | 12.4 | B |

122001
SS Virginis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 7.0 | G |
| | 11 | 7.4 | Bu |
| | 14 | 7.4 | G |
| | 15 | 6.3 | Ba |
| | 23 | 7.6 | G |
| | 24 | 6.7 | Ba |
| | 26 | 7.6 | Bu |

122532
T Can. Ven.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 11 | 9.7 | Bu |
| | 15 | 10.4 | O |
| | 15 | 10.5 | Ba |
| | 17 | 10.6 | O |
| | 19 | 10.1 | Y |
| | 22 | 10.8 | O |
| | 26 | 10.0 | Bu |
| | 26 | 10.2 | G |

*122803*
Y Virginis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 15 | 10.0 | Ba |
| | 24 | 9.8 | Ba |

123160
T Urs. Maj.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 1 | 10.8 | G |
| | 4 | 10.6 | G |
| | 6 | 10.0 | M |
| | 12 | 9.3 | M |
| | 13 | 9.1 | Ba |
| | 13 | 9.0 | St |
| | 13 | 9.2 | G |
| | 14 | 9.0 | G |
| | 16 | 8.8 | S |
| | 17 | 9.0 | M |
| | 17 | 9.2 | O |
| | 17 | 8.8 | St |
| | 17 | 8.9 | G |
| | 20 | 8.6 | Ba |
| | 20 | 8.6 | Br |
| | 21 | 8.5 | Br |
| | 22 | 8.5 | O |
| | 22 | 8.6 | Hu |
| | 23 | 8.4 | Ba |
| | 23 | 8.9 | G |
| | 24 | 8.3 | B |
| | 24 | 8.2 | M |
| | 25 | 8.2 | O |
| | 27 | 8.8 | G |

123307
R Virginis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 6 | 9.5 | M |
| | 11 | 9.5 | Bu |
| | 15 | 10.0 | Ba |
| | 17 | 9.9 | O |
| | 20 | 10.7 | Br |
| | 24 | 10.7 | Ba |
| | 26 | 9.8 | Bu |

123961
S Urs. Maj.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 1 | 7.8 | G |
| | 4 | 7.4 | G |
| | 6 | 7.4 | G |
| | 6 | 8.2 | M |
| | 7 | 7.8 | Ba |
| | 9 | 8.0 | L |
| | 10 | 7.8 | B |
| | 11 | 8.2 | Bu |

VARIABLE STAR OBSERVATIONS Mar.-Apr., 1914.—Continued.

**S Urs. Maj.**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 12 | 8.1 | O |
| | 12 | 8.3 | M |
| | 13 | 7.9 | G |
| | 13 | 7.5 | Ba |
| | 14 | 7.7 | G |
| | 15 | 8.3 | Bb |
| | 15 | 7.8 | C |
| | 16 | 8.0 | C |
| | 16 | 8.7 | S |
| | 17 | 8.1 | C |
| | 17 | 7.8 | M |
| | 17 | 8.2 | O |
| | 17 | 7.6 | G |
| | 18 | 8.1 | Br |
| | 19 | 8.0 | Br |
| | 20 | 7.9 | Br |
| | 20 | 7.7 | Ba |
| | 22 | 7.2 | Hu |
| | 22 | 8.4 | Bb |
| | 22 | 8.1 | O |
| | 23 | 7.8 | G |
| | 23 | 7.8 | B |
| | 23 | 7.6 | Ba |
| | 24 | 8.5 | Bb |
| | 24 | 8.2 | M |
| | 25 | 8.2 | O |
| | 25 | 8.5 | Bb |
| | 26 | 8.4 | Bu |
| | 27 | 7.6 | G |
| | 28 | 8.6 | Bb |
| | 31 | 8.6 | Bb |
| | 31 | 8.1 | J |

**124204**
**RU Virginis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 15 | 12.5 | Ba |
| | 24 | 12.0 | Ba |

**124606**
**U Virginis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 13 | 9.6 | Bu |
| | 20 | 10.4 | Br |
| | 21 | 10.7 | Br |
| | 23 | 10.9 | Ba |
| | 26 | 9.8 | Bu |

***132422***
**R Hydrae**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 5.1 | G |
| | 6 | 4.8 | G |
| | 19 | 4.5 | L |
| | 23 | 4.0 | G |
| | 24 | 5.0 | R |
| | 26 | 4.0 | G |

***132706***
**S Virginis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 14 | 9.0 | Bu |
| | 23 | 9.3 | Ba |
| | 28 | 8.6 | Bu |

**133273**
**T Urs. Min.**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 22 | 11.9 | Bb |
| | 24 | 12.4 | Ba |
| | 24 | 11.9 | Bb |
| | 25 | 11.8 | Bb |
| | 28 | 11.7 | Bb |
| | 31 | 11.7 | Bb |

**134440**
**R Can. Ven.**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 7.8 | Ba |
| | 12 | 8.0 | M |
| | 13 | 7.4 | Ba |
| | 14 | 7.6 | Bu |
| | 15 | 7.5 | L |
| | 17 | 7.1 | O |
| | 17 | 7.7 | M |
| | 20 | 7.0 | Ba |
| | 22 | 7.1 | O |
| | 23 | 6.9 | Ba |
| | 26 | 6.9 | Hu |
| | 26 | 7.0 | G |
| | 28 | 7.6 | Bu |

**141567**
**U Urs. Min.**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 7 | 8.7 | Ba |
| | 13 | 8.8 | Ba |
| | 20 | 8.5 | Ba |
| | 23 | 8.2 | O |
| | 23 | 8.5 | Ba |
| | 25 | 8.4 | O |
| | 26 | 8.5 | Hu |
| | 26 | 9.0 | S |

**141954**
**S Boötis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 13 | 8.6 | Ba |
| | 13 | 8.7 | O |
| | 14 | 8.8 | Bu |
| | 14 | 8.8 | L |
| | 17 | 8.5 | O |
| | 19 | 8.8 | Br |
| | 20 | 9.0 | Br |
| | 21 | 8.9 | Br |
| | 22 | 8.8 | O |
| | 23 | 8.5 | Ba |
| | 26 | 8.6 | O |
| | 26 | 8.4 | S |
| | 28 | 8.6 | Bu |
| 4 | 3 | 8.3 | O |
| | 5 | 8.1 | P |

**142539**
**V Boötis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 1 | 9.7 | G |
| | 4 | 9.6 | G |
| | 9 | 9.7 | L |
| | 14 | 9.2 | G |
| | 14 | 9.6 | Bu |
| | 15 | 9.2 | Ba |

**V Boötis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 17 | 9.1 | G |
| | 19 | 9.4 | Br |
| | 20 | 9.4 | Br |
| | 21 | 9.4 | Br |
| | 23 | 9.1 | G |
| | 27 | 8.8 | G |
| | 28 | 9.4 | Bu |
| 4 | 3 | 8.5 | O |
| | 5 | 8.6 | P |

**142584**
**R Camelop.**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 5 | 8.4 | G |
| | 6 | 8.3 | G |
| | 12 | 8.2 | O |
| | 13 | 8.7 | L |
| | 14 | 8.0 | Bu |
| | 14 | 8.3 | G |
| | 17 | 8.4 | O |
| | 17 | 8.4 | G |
| | 20 | 8.4 | Ba |
| | 20 | 8.7 | O |
| | 22 | 8.6 | O |
| | 23 | 8.4 | Ba |
| | 23 | 8.3 | G |
| | 26 | 8.7 | O |
| 4 | 3 | 9.0 | O |

**143227**
**R Boötis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 8.8 | G |
| | 9 | 8.6 | L |
| | 15 | 9.2 | Ba |
| | 21 | 10.1 | Br |
| | 23 | 10.0 | Ba |
| | 23 | 10.2 | G |

**144918**
**U Boötis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 14 | 9.8 | Bb |
| | 20 | 11.3 | Ba |
| | 22 | 10.0 | Bb |
| | 24 | 10.1 | Bb |
| | 25 | 10.1 | Bb |
| | 28 | 10.2 | Bb |
| | 31 | 10.1 | Bb |

**151731**
**S Cor. Bor.**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 22 | 7.6 | Ba |

**153378**
**S Urs. Min.**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 2 | 11.5 | G |
| | 2 | 12.3 | L |
| | 9 | 11.6 | L |
| | 18 | 12.0 | L |
| | 23 | 12.2 | Ba |
| | 26 | 11.3 | Hu |

**154428**
**R Cor. Bor.**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 3 | 6.0 | G |
| | 4 | 5.8 | G |
| | 6 | 5.7 | G |
| | 14 | 6.0 | J |
| | 14 | 6.0 | Bu |
| | 15 | 5.8 | Ba |
| | 17 | 5.8 | Br |
| | 18 | 5.9 | Br |
| | 19 | 5.9 | L |
| | 20 | 5.8 | Ba |
| | 22 | 5.8 | Ba |
| | 23 | 6.2 | G |
| | 23 | 5.8 | Ba |
| | 24 | 5.8 | Ba |
| | 26 | 6.2 | G |
| | 26 | 5.8 | Ba |
| | 28 | 5.8 | Bu |
| | 31 | 6.1 | J |
| 4 | 3 | 6.0 | O |
| | 5 | 5.8 | P |

**154539**
**V Cor. Bor.**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 22 | 7.8 | Ba |
| | 23 | 8.0 | G |
| | 27 | 8.3 | G |

**154615**
**R Serpentis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 22 | 5.4 | Ba |

**160210**
**U Serpentis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 22 | 7.8 | Ba |

**162119**
**U Herculis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 22 | 7.0 | Ba |

**163172**
**R Urs. Min.**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 21 | 10.6 | Br |
| | 23 | 10.7 | Ba |

**163266**
**R Draconis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 8 | 8.3 | Ba |
| | 16 | 8.0 | S |
| | 19 | 7.8 | Y |
| | 20 | 7.8 | Br |
| | 20 | 7.9 | Ba |
| | 23 | 7.7 | Ba |
| | 31 | 7.8 | J |

**164055**
**S Draconis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 17 | 9.2 | G |

**164715**
**S Herculis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 22 | 12.2 | Ba |

**175458**
**T Draconis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 23 | 10.9 | Ba |

**180531**
**T Herculis**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 22 | 8.0 | Ba |
| 4 | 5 | 7.6 | P |

**181136**
**W Lyrae**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 10.3 | G |
| | 17 | 11.0 | M |

***184205***
**R Scuti**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 4.8 | G |

**193449**
**R Cygni**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 7.0 | G |
| | 17 | 7.8 | M |
| | 24 | 6.6 | L |

**193732**
**TT Cygni**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 8.0 | G |

**194048**
**RT Cygni**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 6.8 | G |
| | 17 | 8.0 | M |
| | 21 | 7.2 | Br |
| | 24 | 6.6 | L |

**194348**
**TU Cygni**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 17 | 11.0 | M |
| | 24 | 12.5 | L |

**194632**
**χ Cygni**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 10.2 | G |
| | 17 | 10.8 | M |
| | 31 | 9.2 | Bb |

**200647**
**SV Cygni**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 9.1 | G |

**200938**
**RS Cygni**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 6.5 | G |

**201647**
**U Cygni**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 10.5 | G |

**202539**
**RW Cygni**

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 3 | 4 | 8.5 | G |
| | 17 | 9.2 | M |

VARIABLE STAR OBSERVATIONS Mar.-Apr., 1914.—Continued.

| 202938 SZ Cygni | | | | 210868 T Cephei | | | | 213678 S Cephei | | | | 213843 SS Cygni | | | | 234982 V Cephei | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mo. | Day | Est. | Obs. | Mo. | Day | Est. | Obs. | Mo. | Day | Est. | Obs. | Mo. | Day | Est. | Obs. | Mo. | Day | Est. | Obs. |
| 3 | 17 | 9.4 | M | 3 | 13 | 10.7 | L | 3 | 22 | 11.5 | Ba | 3 | 4 | 11.6 | G | 3 | 15 | 6.7 | C |
| | 21 | 10.2 | Br | | 22 | 9.8 | Ba | | | | | | 17 | 10.3 | M | | 16 | 6.8 | C |
| | | | | | | | | | | | | | 31 | 11.4 | Bb | | 17 | 6.5 | C |

No. of observations, 883; No. of stars observed, 128; No. of observers, 20.

Mr. Bancroft as usual ranks first in the number of observations sent in by any observer this month. He made a total of 235 observations of 94 variables, a splendid record. In addition to this he is to be highly congratulated on his article on "Variable Star Observing in the last issue of POPULAR ASTRONOMY which was illustrated by some beautiful curves drawn from his own observations.

Mr. Lemont Barbour, of New York City, "Bb" deserves credit for the good start he has made, making his first contribution to the reports this month, 43 observations of 10 variables.

Dr. Edward Gray, has published in "*Scientific American*" the issue of April 4 an article of interest to all our members entitled "Attractiveness of Variable Star Observing", in which he clearly sets forth the fascination and practical nature of the work. It is an article that should win us many recruits, and the thanks of the Association are due the author for thus furthering our progress.

The Secretary recently received a communication from the Comité de Bibliographie et d'Etudes Astronomiques of the Observatoire Royal de Belgique, requesting data relative to our organization to be published in the forthcoming edition of "Observatoires Astronomiques et les Astronomes." This data, which includes the name and address of each active member, with the diameter of aperture of glass used, has been forwarded for publication.

From Mr. McAteer's observation of 213843 SS Cygni 10.3 Mg. April 17 it seems likely that we missed observing a maximum shortly prior to this date.

Dr. Hartwig cites the following calculated dates of maxima:

| | | |
|---|---|---|
| 015354 | U Persei | April 12 |
| 021024 | R Arietis | March 18 |
| *120905* | T Virginis | April 20 |
| 123961 | S Urs. Maj. | April 24 |
| 193449 | R Cygni | April 28 |

From the *English Mechanic* the following dates of maxima are quoted:

| | | |
|---|---|---|
| March | 3 | 162119 U Herculis |
| | 17 | *021403 o* Ceti |
| | 27 | 065355 R Lyncis |

The variable 070310 R Can. Min. appears to have been making history during the past month. The Annals of the H. C. O., Hartwig's and Chandler's catalogues state the minimum as 10.0 magnitude. The observations during the past month indicate a fainter magnitude at this minimum. Such features of our work as this lend zest and interest to each observation, and are the best possible evidence of the practical nature of variable star observing.

A recent letter from Mr. C. L. Brook, Director of the V.S.S. of the B.A.A., confirms the suspicion that we failed to observe the last maximum of 074922 U Geminorum which probably occurred the 16th or 17th of February. Mr. Brook observed the variable at 9.6 magnitude February 18, and Mr. Bancroft on the 21st observed it at 10.6 magnitude. We hope to observe the next maximum which is due now. This variable should be observed by all our members at every opportunity.

Thanks to the generosity of Professor E. C. Pickering, our collection of blue prints is offered for sale at a nominal cost to observers outside our ranks. There may be many foreign observers who will be glad of the opportunity of purchasing such a valuable set of charts at so small a cost. A note regarding the matter is published elsewhere in this issue. Professor Pickering in a recent letter to the secretary expresses the wish that observers with large telescopes direct their attention particularly to the variables that are faint.

The following members contributed to this report:—Messrs. Bancroft, Barbour, Bouton, Bruseth, Burbeck, Craig, Eaton, Gray, Hunter, Jacobs, Lacchini, McAteer, Olcott, Putnam, Richter, Stepka, Vrooman, Miss Swartz, Miss Young.

WILLIAM TYLER OLCOTT,
Corresponding Secretary.

Norwich, Ct. April 10, 1914.

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## GENERAL NOTES.

**Dr. John A. Brashear,** of Pittsburg, recently delivered two illustrated lectures at the University of Illinois on "The contribution of Photography to our Knowledge of the Stellar Universe" and "Engineering Problems in the Construction of Large Telescopes." The lecture on celestial photography was held in the university auditorium with an audience of fifteen hundred persons. (*Science* April 17, 1914.)

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**Mr. Storrs B. Barrett** has been elected assistant professor at the Yerkes Observatory.

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**Mr. Oliver J. Lee** has been elected instructor in astronomy at the University of Chicago.

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**Dr. Adrian van Maanen** of the Mount Wilson Observatory will start on May 1 for Europe. He will visit his home in Holland and return to Mt. Wilson the latter part of next July. Dr. van Maanen spent his first year in this country at the Yerkes Observatory and has now been at the Mt. Wilson Observatory for two years.

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**Professor A. S. Eddington** has been elected director of the Cambridge Observatory in succession to the late Sir Robert Ball. Readers who are unfamiliar with Cambridge are likely to find the recent reorganization of the astronomical work there somewhat confusing. The University now possesses two observatories, which, however, stand on the same grounds. The one, devoted mainly to astronomy of position, is called simply "The Observatory"; and it is to this that the appointment relates. The other is the Solar Physics Observatory, which includes also the astrophysical work; this is under the direction of the Professor of Astrophysics, Professor H. F. Newall. (*The Observatory*, April 1914.)

**Dr. J. O. Backlund,** director of the Russian Royal Observatory, at Pulkowa, has been awarded the Bruce Medal of the Astronomical Society of the Pacific, for his work on the motion and brightness of Encke's comet, his investigation on the motion of minor planets of the *Hecuba* type, and other astronomical research.

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**Dr. Henry Norris Russell,** professor of Astronomy in Princeton University, lectured before the Columbia Chapter of Sigma Xi on March 24, the subject being "Eclipsing Variable Stars."

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**Publications of the Vassar Observatory, No. 3.**—This volume of more than 200 pages was issued during the latter part of last year. It is devoted to a record of the observations of variable stars made at the Vassar Observatory during the years 1901-12 under the direction of Miss Mary W. Whitney. This volume was prepared for publication by the present director, Miss Caroline E. Furness. It contains a description of the methods and instruments used in the observations. Following this are given in tabular form the observations of 230 variables. This volume contains much valuable data and will be found very interesting by observers of variable stars both for its method and as a reference work.

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**Napier Tercentenary Celebration, 1914.**—The following notice issued by the General Secretary of the Royal Society of Edinburgh is of interest to anyone who realizes the great advantage gained by the use of logarithms in any computational work.

John Napier's *Logarithmorum Canonis Mirifici Descriptio* was published in 1614; and it is proposed to celebrate the tercentenary of this great event in the history of mathematics by a Congress, to be held in Edinburgh on Friday, 24th July 1914, and following days.

The Celebration is being held under the auspices of the Royal Society of Edinburgh, on whose invitation a General Committee has been formed, representing the Royal Society of London, the Royal Astronomical Society, the Town Council of Edinburgh, the Faculty of Actuaries, the Royal Philosophical Society of Glasgow, the Universities of St. Andrews, Glasgow, Aberdeen, and Edinburgh, the University College of Dundee, and many other bodies and institutions of educational importance.

The Celebration will be opened on the Friday with an Inaugural Address by Lord of Appeal Sir J. Fletcher Moulton, F. R. S., LL.D, (Edin.), etc., followed by a Reception given by the Right Honourable the Lord Provost, Magistrates and Council of the City of Edinburgh. On the Saturday and Monday the historical and present practice of computation and other developments closely connected with Napier's discoveries and inventions will be discussed.

A memorial Service will be held in St. Giles' Cathedral on the Sunday.

Among many who have expressed a warm interest in the Celebration and who hope to take part in the Congress, may be mentioned Professor Andoyer, Paris; Professor J. Bauschinger, Strassburg; Professor Hume Brown, Historiographer Royal for Scotland; Professor F. Cajori, Colorado, U.S.A.; Professor G. A. Gibson, Glasgow; Dr. J. W. L. Glaisher, Cambridge; Professor Lang, St. Andrews; Professor Macdonald, Aberdeen; Professor E. Pascal, Naples; Professor Karl Pearson, London; Professor Eugene Smith, New York; Professor Steggall, Dundee; Professor Whittaker, Edinburgh.

**The One-Hundred-Inch Telescope.**—The following account of the progress being made in the construction of the 100-inch reflecting telescope at the Mount Wilson Solar Observatory, is taken from Professor Hale's annual report for the year 1913.

In the last annual report the peculiar changes of figure observed when testing the 100-inch mirror were described. When the glass was hung on edge for testing, the figure was found to alter when the disk was rotated in its own plane. The observed effect was attributed by Mr. Ritchey to different degrees of compression of the disk along different diameters, under the pressure of its own weight.

To test the compression hypothesis a weight of five tons was supported on the upper edge of the glass, at the position angle corresponding to the "weak" diameter. When the point of support was brought into the neutral plane of the glass, found by experiment to be 5¾ inches from the rear surface, the figure was seen to be precisely the same as that observed when no pressure was applied. On either side of this plane the pressure introduced a component at right angles to the face of the disk, and thus caused a distortion of the glass. The solution of the whole difficulty was thus immediately suggested. It was found that the edge-band support, though made with unusual care, had not been properly applied. As soon as this was discarded and the glass allowed to rest on a shore-block of wood, with the point of support lying in the neutral place, the figure was not changed in the least by rotation of the disk. Incidentally it appears that the difficulty of securing suitable edge-supports for such mirrors has been exaggerated; a very simple device will serve perfectly if the pressure is applied in the proper plane.

As a further test of the suitability of the glass for use in the telescope, its figure was examined after the temperature of the room had been reduced to 45° F., and maintained at this point for several days. As no change in figure was observed, the temperature was raised to 95° F. and the tests repeated. These also showed the same figure as before. It thus appears so be safe to use the disk under the actual conditions of observation.

As a check on the visual knife-edge tests, they were repeated photographically and the figure was further controlled by means of the Hartmann test. The measures and reductions of the photographs were made by Mr. Adams, Miss Lasby, and Miss Burwell.

It is appropriate to express here our hearty acknowledgments of the unflagging interest and persistence of the French Plate Glass Company, which pursued costly experiments through several years in the hope of producing a flawless disk. We are also indebted to the Count de la Baume Pluvinel for his kindness in testing at St. Gobain a 100-inch disk of less thickness than the one selected.

Since the acceptance of the disk the work of figuring has gone on steadily, and has now advanced to a point where parabolizing may soon be undertaken. The figuring of the 60-inch plane mirror, for use in testing the 100-inch, has also been carried on simultaneously and it will be ready for use as soon as it is needed.

In the work of designing the mounting much practical advantage has been derived from the suggestions of Professor Peter Schwamb, formerly of the Massachusetts Instiuute of Technology, who has been engaged as our representative to superintend the work of construction at the Fore River Shipyards in Quincy, Massachusetts. Several valuable suggestions offered by Professor Schwamb have been incorporated in the design, and the work of construction is now under way.

The design for the steel building and dome for the 100-inch telescope was completed about June 1 by Messrs. D. H. Burnham & Co. of Chicago, and bids were secured from several contractors. Unfortunately, however, the figures were considerably in excess of the architects' estimates, on account of an increase in the

market price of steel. After waiting several months, a new set of bids is being obtained, and the indications are that a very substantial reduction in cost will thus be effected. As our building program did not include the erection of the dome this year, there will be no delay on account of this experience. It is expected that the steel will be shipped to Pasadena early in 1914, and the work of hauling it to Mount Wilson can be undertaken in the spring in ample time for the opening of our construction season.

The greater part of the construction work on Mount Wilson during the past year has centered about the 100-inch telescope pier and the foundations for the building. The site, which had been roughly graded the previous year, has been lowered an additional three feet and a concrete retaining-wall built around the south and west portions to prevent washing by the winter rains. The foundations for the building, consisting of two concentric rings of concrete piers, each 6 feet square at the base and 6 feet high, and amounting to 40 in number, were completed early in July and work was then commenced on the telescope pier. This is now nearly finished.

The pier proper measures 20 by 45 feet at the ground-level and is 32 feet 11 inches in height. On the south side is a long extension pier with the top sloping at an angle corresponding to the latitude of the observatory. This pier is designed to carry large fixed spectrographs and other apparatus intended for use with the telescope in the coudé form. In order, however, to avoid the necessity of constructing a pier with a very large upper surface the plan was adopted of mounting the instruments on brackets attached to its vertical face. The optical axis of the telescope passes about two feet outside of this face, a distance sufficient to allow for the use of the largest spectrographs. The height of the pier is such that a concave-grating spectrograph of 21 feet radius or a plane-grating spectrograph of 30 feet focal length may be employed if desired. The whole pier is inclosed by an outer concrete wall and roof to assist in maintaining a constant temperature.

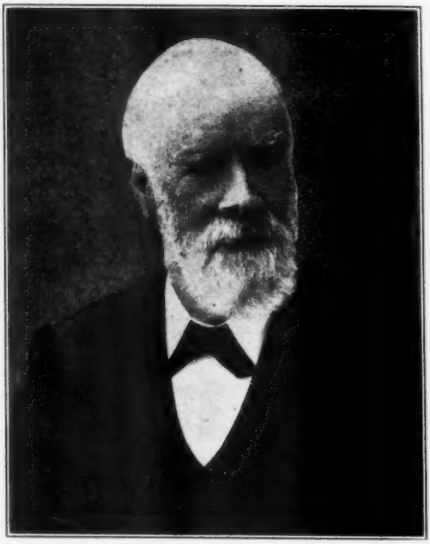
The telescope pier itself is hollow in construction, with three heavily reinforced floors running across it at different elevations. The walls are also strongly reinforced and further strengthened by four buttresses on the outside, two each on the east and west sides. The first floor, at a distance of 16 feet from the ground, is designed to carry a large water-tank, which will form the reservoir for the water-circulation system enveloping the 100-inch mirror. At a height of 25 feet is the floor on which the driving-clock, worm-gear, and quick-motion right-ascension mechanism will stand. At the northern end on this floor is the room planned for the silvering of the large mirror. The electric elevator used for handling the mirror moves up and down through an opening 14 feet in diameter near the center of the pier.

The top of the pier consists of a circular concrete floor 11 inches thick and 53 feet 10 inches in diameter. On the east and west sides it is supported by massive reinforced concrete brackets extending outward from the pier. A metal wall about 8 feet high reaches from the edge of this floor to the level of the main steel floor of the building and the joint between the two may be made air-tight by means of a water seal, if found desirable.

With the completion of this pier the concrete construction work will be finished with the exception of the floor at the ground-level. This will probably be delayed until after the erection of the building and dome and the heavier parts of the telescope mounting.

VIEW OF NELSON, NEW ZEALAND, SHOWING THE "FRINGE", THE PROPOSED SITE FOR THE CAWTHRON SOLAR PHYSICS OBSERVATORY.

**The New ZealandCawthron Solar Physics Observatory.**—The accompanying photographs are taken from the Auckland paper *Progress* for June 1913. The one shows the city of Nelson, New Zealand, and the mountains back of it where it is proposed to locate the new observatory. The other is a photograph of Mr, Thomas Cawthron who donated twelve thousand pounds for the purpose of building, endowing and equipping the observatory and thus completing the chain of solar observatories round the world.



THOMAS CAWTHRON, WHO MADE THE GIFT OF A SOLAR PHYSICS OBSERVATORY TO THE CITY OF NELSON, NEW ZEALAND.

**New Atmospheric Gases.**—In a paper read before the British Association meeting at Birmingham, F. W. Aston reported investigations which indicate that neon, one of the rare gases of the atmosphere, is really a mixture of two gases, which are identical in all their properties except atomic weight. That of the heavier is 22.1, and of the lighter 19.9. Ordinary neon appears to contain about 12.5 per cent of the heavier gas. The spectra of the two gases appear to be identical. (*Scientific American*, March 21,1914.)

**Standard Time in German East Africa.**—Uniform time of the meridian 37° 30′ east was officially adopted in German East Africa on October 1, 1913.

**Actual Time of Signals from the U. S. Naval Observatory March, 1914.**

| Day | Time of Signals Noon | | | | Time of Signals 10:00 P. M. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | h | m | s | | h | m | s | | |
| 1 | 12 | 0 | 0.01 | +.01 | 9 | 59 | 59.99 | —.01 | Sunday |
| 2 | 12 | 0 | 0.00 | .00 | 9 | 59 | 59.99 | —.01 | |
| 3 | 12 | 0 | 0.00 | .00 | 9 | 59 | 59.99 | —.01 | |
| 4 | 11 | 59 | 59.95 | —.05 | 10 | 0 | 0.02 | +.02 | |
| 5 | 12 | 0 | 0.04 | +.04 | 10 | 0 | 0.03 | +.03 | |
| 6 | 12 | 0 | 0.06 | +.06 | 10 | 0 | 0.06 | +.06 | |
| 7 | 12 | 0 | 0.09 | +.09 | 10 | 0 | 0.08 | +.08 | |
| 8 | 12 | 0 | 0.09 | +.09 | 10 | 0 | 0.07 | +.07 | Sunday |
| 9 | 12 | 0 | 0.12 | +.12 | 9 | 59 | 59.97 | —.03 | |
| 10 | 11 | 59 | 59.99 | —.01 | 9 | 69 | 59.95 | —.05 | |
| 11 | 11 | 59 | 59.97 | —.03 | 9 | 59 | 59.98 | —.02 | |
| 12 | 11 | 59 | 59:96 | —.04 | 10 | 0 | 0.03 | +.03 | |
| 13 | 1 | 0 | 0.09 * | +.09 | 10 | 0 | 0.01 | +.01 | |
| 14 | 12 | 0 | 0.04 | +.01 | 10 | 0 | 0.03 | +.03 | |
| 15 | 12 | 0 | 0.04 | +.04 | 10 | 0 | 0.05 | +.05 | Sunday |
| 16 | 12 | 0 | 0.05 | +.05 | 10 | 0 | 0.06 | +.06 | |
| 17 | 12 | 0 | 0.05 | +.05 | 10 | 0 | 0.04 | +.04 | |
| 18 | 12 | 0 | 0.05 | +.05 | 10 | 0 | 0.04 | +.04 | |
| 19 | 11 | 59 | 59.97 | —.03 | 9 | 59 | 9.96 | —.04 | |
| 20 | 11 | 59 | 59.94 | —.06 | 9 | 59 | 59.96 | —.04 | |
| 21 | 11 | 59 | 59.93 | —.07 | 10 | 0 | 1.01 | +.01 | |
| 22 | 12 | 0 | 0.03 | +.03 | 10 | 0 | 0.02 | +.02 | Sunday |
| 23 | 12 | 0 | 0.04 | +.04 | 10 | 0 | 0.03 | +.03 | |
| 24 | 12 | 0 | 0.01 | +.01 | 9 | 59 | 59.99 | —.01 | |
| 25 | 11 | 59 | 59.98 | —.02 | 9 | 59 | 59.98 | —.02 | |
| 26 | 11 | 59 | 59.98 | —.02 | 9 | 59 | 59.94 | —.06 | |
| 27 | 11 | 59 | 59.94 | —.06 | 9 | 59 | 59.94 | —.06 | |
| 28 | 11 | 59 | 59.95 | —.05 | 9 | 59 | 59.93 | —.07 | |
| 29 | 11 | 59 | 59.95 | —.05 | 9 | 59 | 59.94 | —.06 | Sunday |
| 30 | 11 | 59 | 59.93 | —.07 | 9 | 59 | 59.93 | —.07 | |
| 31 | 11 | 59 | 59.92 | —.08 | 9 | 59 | 59.93 | —.07 | |

(+) slow
(—) fast

* 1:00 P.M.

April 6, 1914.

J. A. HOOGEWERFF,
Captain U. S. Navy
Superintendent.

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**The Katmai Dust Cloud,** which caused a general haziness of the atmosphere over much of the northern hemisphere, reaching a marked maximum in August, 1912, appears now to have practically disappeared. As pointed out by Professor Kimball, the duration of this cloud was somewhat less than that due to the eruptions of 1902-03, which lasted two years, and markedly less than that of the dust ejected by the great Krakatoa eruption of 1883. (*Scientific American*, March 21, 1914.)

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**Variable Star Charts.**—The American Association of Variable Star Observers offers to all those interested in the observation of variable stars a valuable set of charts, in blue print, of long period variable stars, at a remarkably low price.

These charts, 240 in number, are a combination of the Harvard College Observatory photographic charts, the Durchmusterung chart enlargements, and charts from Father Hagen's Atlas. In every case comparison stars are designated with light values reduced to a common standard, that adopted by the Harvard College Observatory.

The charts may be purchased singly at five cents each, or the whole set for ten dollars, postpaid. The sets are printed on large sheets ten to sixteen to the sheet. The H. C. O. charts are 7½ x 10½, the Hagen charts 8½ inches square.

One of the drawbacks to variable star observing heretofore has been the high cost of the valuable and indispensable Atlas Stellarum Variabilium of Father Hagen. No claim is made that the charts advertised are the equal of the Hagen charts, but they are an inexpensive, serviceable and valuable set of charts that should be in the hands of all observers of long period variable stars not provided with adequate or sufficient material. The charts are furnished gratis to all members of the Association and are offered to other observers through the courtesy of Professor E. C. Pickering, Director of the Harvard College Observatory. Those interested are requested to address the undersigned.

WILLIAM TYLER OLCOTT.
Norwich, Conn.

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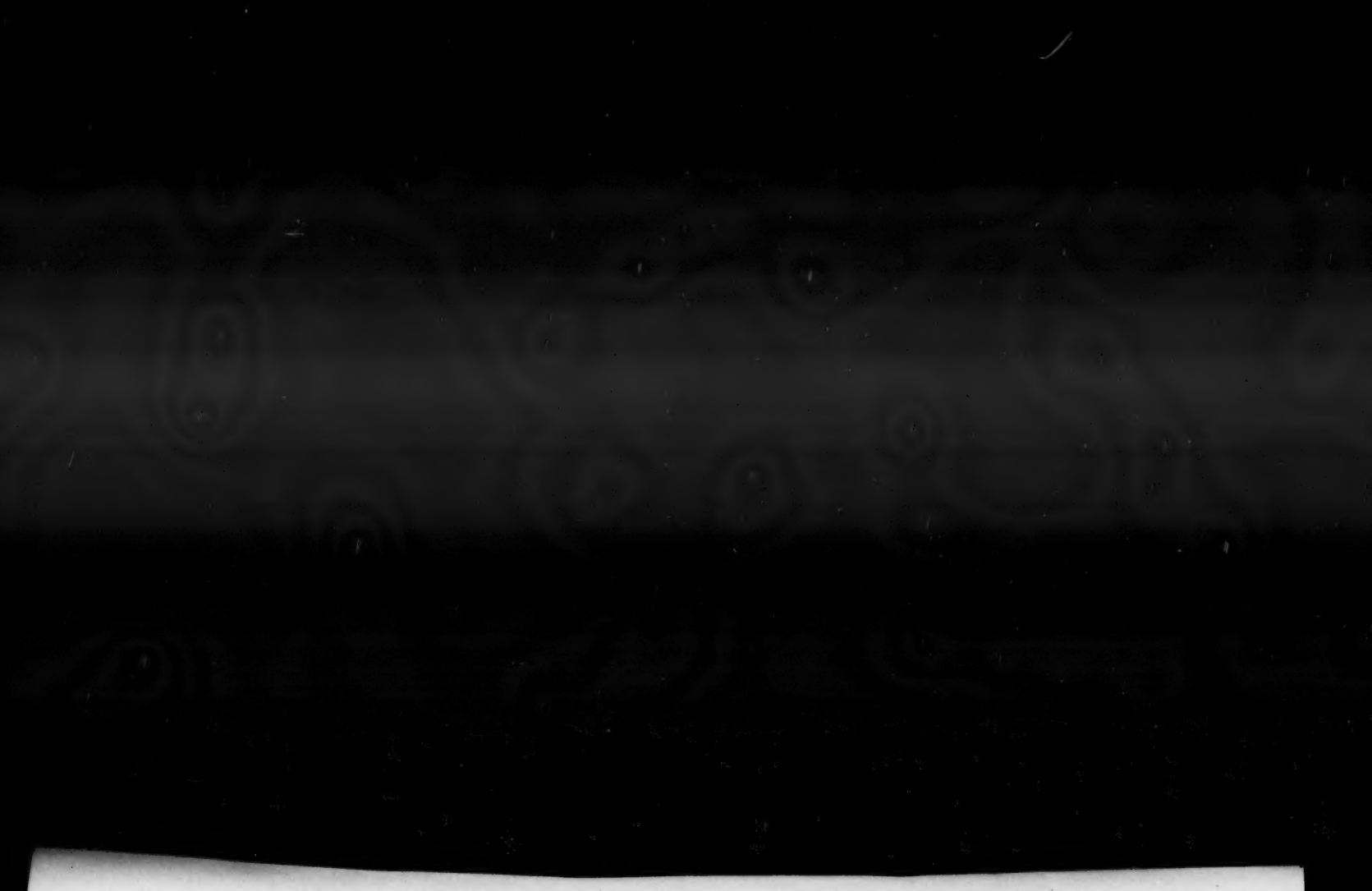
**Die Veränderlichen Sterne.**—Erster Band: Geschichtlich-Technicher Teil. Von Johann Georg Hagen, S. J. Erste Lieferung; Die Ausrüstung des Beobachters. Freiburg: Herdersche Verlagshandlung, 1913. Quarto, XV + 152 pp. M 10.

Amateur variable-star observers will have a hearty welcome for this timely and much needed book by the well-known author of the *Atlas of Variable Stars*. The branch of observational astronomy has been the most attractive to amateurs because useful results could be had with a minimum of instrumental equipment and experience. But such amateurs have experienced difficulty in finding directions for work, in regard to choice of stars, methods of observation and reduction, guarding against sources of error, and other practical points. Father Hagen has now supplied part of this needful material, and the remainder will follow in the latter parts of the volume. Though only the first of the four parts is before us, it is safe to say that no previous work contains one-quarter of the useful material to be found in this part.

The title of Part 1 is "The Equipment of the Observer", and is broadly interpreted to include an intelligent idea of the history of variable star observations, the significance of variability, knowledge of methods of observation and the preparation and publication of results, classification, number and distribution of variables, catalogs, charts and ephemerides, choice of instruments for certain classes of stars and choice of stars to suit the observer's equipment; and last but perhaps most important—the preparation of a useful observing program, which is becoming more difficult as the number of known variables increases at such an astonishing rate. The work deals particularly with visual observations without the aid of photometric appliances.

English readers will be pleased to find that it is written in a clear and simple style, with none of the involved constructions which make some German books so hard to read. The type and press-work are excellent, and the price $2.70 net, is low when the quality is considered. An English translation is much to be desired, but can hardly be expected of so voluminous a work as is planned. The remaining parts of Volume I are to deal with—

II. Methods of Observation,
III. Reduction of Observations,
IV. Elements of Light-change.

Volume II, dealing with the theoretical side of the subject, will be prepared by Father J. Stein. American purchasers can secure copies from Herder's St. Louis branch, at 17 South Broadway.

J. A. PARKHURST.